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NEW METHODS IN SPECTROSCOPY[1]

By Professor GEORGE R. HARRISON

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IN expressing my appreciation of, and gratitude for, the high honor which is bestowed in the award of the Rumford Medals, I am mindful of the obligation which is laid upon a medallist to hold in mind the true significance of such an award. In all human affairs there are values which are of so intangible a nature as to require frequent concrete symbolization if we are to keep their import before us; this is an occasion of such symbolization. I accept these medals, not as a reward for accomplishment, but as symbolic of a vast array of aspirations which we are gathered here to celebrate: the determination of our society that the search for truth shall be prosecuted diligently; the desire that men shall be encouraged in that prosecution; the hope that opportunity for such search may continue in constantly increasing measure; the conviction that every addition to our knowledge of the world in which we live, no matter how slight, brings one step closer the day when men shall be freed from the terrors which have beset them all through the ages—terrors which, though at times they may seem overwhelming, do in fact gradually become less.

Not the least of our duties of realization this evening is the appreciation of the progress which has taken place since 1839 in one of those branches of physical science which Count Rumford desired to further when he arranged for the provision of medals in recognition of researches on heat and light. Later it will be my pleasant duty to recount some of the recent developments in the study of light with which I have had the good fortune to be associated, but before I come to the specific portion of my address which deals with

[1] Address on the occasion of the Award of the Rumford Medals, of the Academy of Arts and Sciences, Boston, October 11, 1939.

"New Methods of Spectroscopy" I should like to think back for a moment to that period of 100 years ago.

Light was then a very mysterious agency, by some scientists supposed to be corpuscular in nature, but showing increasing evidence of an undulatory character. A period of great technical development in optical instruments, and in the control and measurement of light beams, was just beginning; but in so far as the nature of light was concerned the period was one of transition and controversy, and regarding the origin of light almost nothing was known. Newton, 173 years before, had split a beam of white light into its component colors by means of a prism and had recombined these colors into white light with another prism. Most important for our present discussion, however, is the fact that the later days of Count Rumford coincided with the period of greatest activity of Joseph von Fraunhofer, perhaps the inventor of, and certainly the first active experimenter with, the diffraction grating, and constructor of one of the first real spectroscopes.

During the 120-year period which has intervened, the spectroscope has been developed into what appears to be the most powerful single tool which has yet been developed by the hand and mind of man, and one which is suited to a wide variety of purposes. Henry Norris Russell has called the spectroscope the "master key of science," and an examination of the uses of the instrument reveals an astonishingly wide variety of applications. Recently I had occasion to list the various uses of the spectroscope; I found that it has been applied to such remarkably divergent purposes as the measurement of the ratio of the charge of an electron to its mass; the detection of atoms present in a mixture of other atoms in amounts smaller than one in ten million; the measurement of the amounts of lead, arsenic, and other poisons in foodstuffs; observation of the numbers of atoms entering and leaving molecules in a solution or vapor; calibration of the vitamin potencies of food samples; determination of the atomic constitution of complex molecules, such as those of hormones and vitamins; measurement of the temperatures, sizes, distances, weights and ages of stars; observation of the number and arrangement of electrons in atoms and of atoms in molecules; the identification of criminals from traces left at the scene of a crime or carried from it; the study of the colors and discolorations of pigments and papers and ceramic glazes; the investigation of the origins and constitutions of minerals; and so on and on.

To the astronomer the spectroscope is at once a yardstick, a thermometer, a chronometer, a stethoscope for star-pulses, an analyzing microscope, a chemical balance and a super-telescope of the heavens. Though without the telescope the spectroscope would have little value to the astronomer, the spectroscope in its turn has multiplied the power of the telescope by perhaps twenty—for though it is the function of a telescope to gather light and focus this in an image or a spot, a spectroscope can separate this light into its component parts and thus lay bare a hundred meanings hidden from the eye.

To the physicist the spectroscope has served as a powerful atomic probe, for with its aid in analyzing the light emitted by atoms he has deduced much about their structures. He has found that light is emitted when atoms or molecules lose energy as the result of transitions of an electron from a position involving greater energy to one involving less; the spectroscope reveals the exact size of the photon which an atom emits under such circumstances, and by means of the quantum theory the physicist can picture what is going on in a tiny atomic system which is not more than ten or twenty billionths of an inch in diameter.

To the chemist, the biologist or the metallurgist, the spectroscope serves as a sensitive analytical instrument, to detect small amounts of impurities or to analyze the atomic constitution of a speck of matter from its emission of light, or its molecular constitution from its absorption of light. Nor is the use of the instrument as a thermometer confined to the astronomer, for the engineer who wishes to determine the temperature of engine flames need only put a transparent window into the cylinder of a motor and use the spectroscope to study the light which is emitted.

Whence spring this wide adaptability and great power of the spectroscope? No detailed analysis is needed to see that they arise from its ability to attack fundamentals; with it the world and the heavens can be studied in terms of the single particles of which they are composed, and these particles in terms of the energy which is their very life. And this power is rendered the greater because it is not merely of a qualitative sort, but is quantitative as well. The human eye can distinguish at best several hundred different wave-lengths or hues of color; the spectroscope can be used to distinguish more than a million. By using an interferometric spectrograph (by a spectrograph is meant a spectroscope arranged to record spectrum lines photographically) it is possible to measure the relative lengths of light waves, themselves less than 1/50,000 of an inch in length, to closer than one part in forty million; thus measurements are obtained which are precise to one trillionth of an inch.

The precision of spectroscopic methods results directly from the fact that light waves can be made to interfere with one another—to reinforce here, giving extra brightness, and to destroy one another at some other point, giving darkness. Great heaps of

waves can be piled up to give a bright spectrum line in one position and complete darkness elsewhere, and from the location of such a spectrum line the length of the waves in it can be uniquely determined.

One very powerful form of spectrograph contains a concave diffraction grating, which may consist of as many as 180,000 narrow grooves ruled uniformly in the space of six inches on the surface of a concave mirror by means of a diamond point. If light which has passed through a narrow slit falls on an array of such grooves which has been ruled with sufficient nicety, the light will be split into rays and sent in directions such that each ray will contain waves of only one length. The rays of various wave-lengths may then be caught on photographic plates spread around a vast circle. The photographic plates, after development, then show the different rays as spectrum lines. When these spectrum lines are located on the plates to within 1/25,000 of an inch, the wave-lengths of the light can readily be determined to less than a millionth of an inch.

The concave diffraction gratings which make this possible have been available for fifty years, but are continually being improved. With their aid extensive study and cataloguing of the spectrum lines emitted by the chemical elements have been carried out. Every atom can emit light waves whose lengths are definite and characteristic of only that type of atom. Any atom or molecule will emit light if struck a hard atomic blow, and since any material object—a star, a drop of blood or a speck of putty—is composed of atoms, any material object can be induced to emit light by heating it until it becomes an incandescent vapor. Thus the presence or absence of atoms of any sort can be determined in any material by a spectroscopic study of the light emitted by it.

Now we approach the specific topic of this discussion. If one is to be able to identify any sort of atom from its pattern of spectrum lines, it is necessary that the wave-lengths of these lines be known accurately and be available for immediate use. The cataloguing of spectrum lines has engaged the attention of many persons during the past fifty years, until now a quarter-million lines produced by the 88 available chemical elements (elements 43, 61, 85 and 87 are in somewhat uncertain states of discovery, but in very definite states of non-availability) have been measured, though not completely catalogued.

Two types of catalogue are needed; one should list the wave-lengths and relative brightnesses of all the spectrum lines which each atom emits, filed under the respective atoms in order of wave-length; the other should list in order the wave-lengths of all known spectrum lines, each entry containing the atom responsible for the emission of that line. Then to identify the atom responsible for some line whose wave-length has been measured, one need only consult a catalogue of the second or dictionary type; to know what lines to expect a given material to emit, one would consult a catalogue of the first or encyclopedia type.

There is a sad lack of up-to-date catalogues of either type. The most extensive catalogue of the first type is that contained in the monumental "Handbuch der Spectroscopie" of H. Kayser, which lists data on about 120,000 lines, though for some forty elements it contains no data determined since 1912. The most extensive catalogue of the second type was also compiled by Kayser and his colleagues, and contains the 27,000 strongest lines of the elements. An extensive search through the spectroscopic literature recently carried out under my direction by a corps of clerks of the Works Progress Administration has revealed that data are now available for some 250,000 atomic spectrum lines. I have recently calculated (and Professor Henry Norris Russell of Princeton informs me that he has arrived at a similar result) that data on about one million atomic lines should be provided to fill the present needs of science for information of this sort. We are therefore forced to conclude that observation and measurement of atomic spectrum lines are at present not more than one fourth complete, with the compilation of spectroscopic data in available form but one eighth complete for the encyclopedia type of information, and one fortieth complete for the dictionary type. This applies only to spectrum lines produced by atoms; for lines produced by molecules the situation is considerably worse.

Hope for rapid improvement in this situation has been somewhat limited by the fact that discovery and measurement of further spectrum lines becomes not merely progressively more difficult, but progressively less interesting. Naturally the stronger lines are discovered first, and a few thousand lines account for nine tenths of the light usually emitted by atoms. As the needs of other sciences for spectroscopic data have come closer to being met, the physicist has found himself with continually widening interests and hence with continually lessening time available for measurements which were becoming increasingly of a routine nature, yet with some three quarters of a million lines, whose wave-lengths and intensities and parent atoms he would like to know, remaining to be discovered and studied.

Progress in the accumulation of spectroscopic data has been doubly slow because the work has been of such a precise and tedious character. A spectrum plate, perhaps 20 inches long, is put on a measuring engine and, by means of a screw accurate to 0.001 mm, is moved until each spectrum line in turn has been centered on the cross-hair of a measuring microscope.

The readings of the screw scale are recorded by hand to six or seven figures for each line. The measurement of one plate containing a thousand or more lines may require two or three full working days, but even then no wave-length figures are available. By using standard lines whose wave-lengths are well known, usually from iron atoms, all the measurements in millimeters must be converted by interpolation into wave-lengths in angstroms, using a factor which is constantly varying; since this interpolation must be to seven-figure accuracy it is carried out manually with computing machines. Often a week or more of hard work elapses before the wave-lengths of the lines on a single plate are reduced and tabulated.

Only persons of skill, training and boundless perseverance have been suited for such work, and it is not surprising that, owing to the calls of less routine work in other fields, the interest of young physicists in this branch of their science has gradually been lessening, though many important results await the accumulation of further spectroscopic data.

I wish that I might state at this point that such considerations induced me to try to do something to remedy this situation, and that as a result the various automatic measuring, computing, recording and sorting devices which I am about to describe were constructed. Such would be far from the truth; even at the risk that the Rumford Committee may wish to reconsider its recommendation and the Academy its award, I must confess that the chain of events which led to these devices arose from what may well have been pure inertia—at any rate, from a disinclination to face a future filled largely with the prospect of turning the handle of a screw with my left hand, while with my right hand I wrote down six-digit numbers obtained by peering alternately through a reading microscope with one eye and at a rather illegible scale with the other.

A brief consideration showed that such a future was not necessary. The first step in avoidance was substitution, for the antiquated scale, of a modern counter device similar to that used on gasoline-station pumps, and a brightly-flashing light and a camera filled with motion picture film for the pen and paper with which the numbers were previously recorded. This cut the time of measuring a plate by two thirds. The next step was the realization that any operation of multiplication, division, subtraction or addition, carried out with much labor even on the best electric calculating machine, could be done instantly and constantly by means of gears during the very process of measurement. Such calculating methods have, of course, been applied in other fields, though perhaps not with the precision required by seven-figure accuracy; however, it will soon be apparent that I have little to report this evening other than the application, to spectroscopic problems, of methods used in radio-telephony, in television, in stroboscopy, in photography and in various other branches of applied physics and of mechanical and electrical engineering. The devices which I shall describe have arisen entirely as the result of the combination of a need with the availability at the Massachusetts Institute of Technology of experts in almost any branch of science or technology whom I had need to consult.

As a result of this combination of circumstances my colleagues in the spectroscopy laboratory and I now find ourselves the still somewhat surprised possessors of a group of machines with which routine operations that previously required much of our time can be carried out on a wholesale basis by non-technical assistants with little training. For example, a spectrographic plate can now be placed on an automatic measuring engine, and an electric motor will cause it to be scanned from end to end by a beam of light which locates the center of each resolved spectrum line somewhat more precisely than was previously done by the eye, instantly computes the wave-length of each line to seven figures in angstroms, and records this wave-length, together with an intensity trace of the contour of the line, on motion picture film. Once the machine is set up as many as 3,000 lines can thus be recorded in 120 seconds. WPA clerks have during the past four years done yeoman service in reading data from the films which came from such machines, correlating and averaging these data and otherwise assisting in the preparation of more complete, uniform and precise catalogues of wave-lengths than were available previously. Only a few weeks ago the first volume[2] appeared of what we hope will be a series of new tables of spectrum lines; this contains the necessary data on the 109,275 strongest lines emitted by the chemical elements in the range 10,000 to 2,000 A, 75,000 from our own measurements, and the remainder from the best measurements of others. In addition, many thousands of lines not previously reported have been discovered and measured, and the work is being carried on with a precision and uniformity which we could hardly have expected in advance.

I shall pass now to a description of the mode of operation of the automatic comparators, and of two other devices which assist in the determination of atomic energy states.[3]

[2] M.I.T. Wavelength Tables. New York: John Wiley and Sons, Inc., 1939.

[3] The material covered in the second half of the acceptance address has been published in the following papers: G. R. Harrison, *Rev. Sci. Inst.*, **3**: 753, 1932, and **4**: 581, 1933 (interval sorter); *Jour. Opt. Soc. Amer.*, 28: 290, 1938 (interval recorder); *Jour. Opt. Soc. Amer.*, 25: 169, 1935, and *Rev. Sci. Inst.*, **9**: 15, 1938 (automatic comparators).

FORCES DRIVING THE RESPIRATORY ACT[1]

A FUNDAMENTAL CONCEPT OF THE INTEGRATION OF MOTOR ACTIVITY

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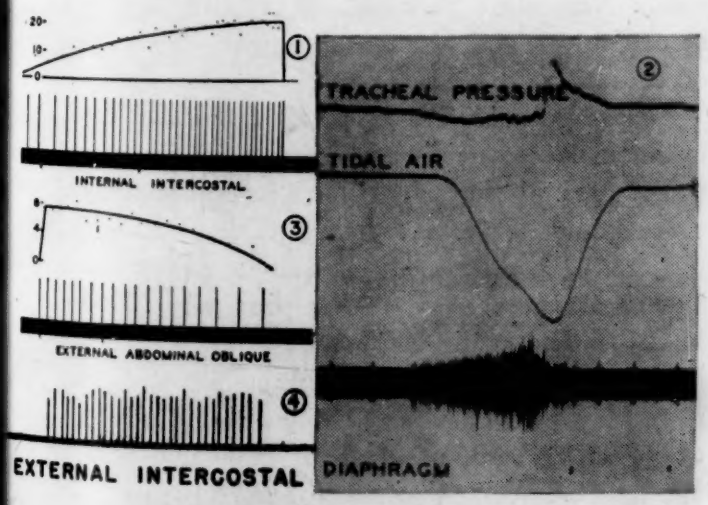
THE report I am about to give is based on the work of many, but I have drawn heavily on the investigations of the physiology staff at Michigan in my interpretations. It will be apparent that the views presented differ from the present-day conceptions of motor integration and respiratory control, and, therefore, it is important to keep in mind a distinction between fact and theory as I proceed.

Life's most basic and most pressing need is a continuing supply of oxygen proportionate to changing energy requirements. Elimination of CO_2 comes next in order, for the CO_2, which is formed in the combustion, increases the hyrogen-ion concentration of the living cell and hampers oxidation in direct proportion to its accumulation. Thus oxygen lack and carbon dioxide excess, by virtue of their effects upon living structures, provide chemical forces which drive the machinery of breathing. These forces act directly on the center and reflexly through the outlying chemoceptors. Though providing steady drives they provoke periodic respiratory activity. Our subject in to-day's symposium is the consideration of the central integration of this rhythmical phenomenon of breathing.

Since the act of breathing is the end resultant of trains of signals coming from the brain and cord, our most direct approach to the problem is a systematic study of these signals. In analyzing the action potentials of respiratory muscles, we learn how the mechanical power is adjusted in each respiratory act. This is illustrated for inspiration in Fig. 1, obtained by the application of closely approximated bipolar electrodes to the surface of the internal intercostal muscle. The frequency of twitch rises slowly during the period of inspiration and then suddenly falls to zero in the early stages of expiration.



FIGS. 1–4

If the electrodes are widely separated, as was the case in Fig. 2, obtained from the diaphragm they combine the potentials of the included fibers in fusillade form, giving again a characteristic triangular pattern. The steadily rising shadow indicates a rising strength of contraction resulting from an increasing frequency of muscle fiber twitch and from a progressive recruitment of new active elements. The rapidly falling shadow depends upon a rapidly decreasing frequency of twitch and upon a rapid decruitment. It indicates a sudden waning of muscular contraction. The slowly rising electrical gradient corresponds with a slow filling of the lungs, as witnessed by the gentle decline of the tidal air and tracheal pressure records. The rapidly falling gradient conforms with the sudden emptying of the lungs.

The purposiveness of such contractions is clear. As the chest expands and the resistance of distortion mounts, the mechanical power of inspiration increases. Once the potential energy for expiration is stored, nothing is lost by a rapid release of tension in the inspiratory muscles. It, therefore, seems of utmost significance that the slowly augmenting pattern of potentials found in the inspiratory muscles is characteristic for the inspiratory phase of breathing at all stations of the respiratory reflex arcs.

The activity of the expiratory muscles during eupneic breathing is definitely less than that of the inspiratory muscles. Nevertheless, we found sufficient number of expiratory discharges to follow them through the expiratory arcs, as was done for the inspiratory signals. In contrast to the inspiratory potentials, which show only one pattern of discharge, the expiratory potentials show two characteristic patterns. One is the rapidly augmenting type, in which the strength of contraction or frequency of discharge falls off slowly, as illustrated by the external abdominal oblique in Fig. 3. It is the mirror image of the slowly augmenting inspiratory pattern. The other is the steady state type, more or less rectangular in shape, as shown in Fig. 4. The rapidly augmenting and the steady state types of discharge like the inspiratory discharges are also found at various stations in the expiratory arcs.

[1] A paper delivered at the symposium on "Respiration" before the American Society for Pharmacology and Experimental Therapeutics, Toronto, 1939.

It may, therefore, be concluded that there are three patterns of discharge common to the respiratory act—the slowly augmenting, the rapidly augmenting and the steady state. These types are subject to minor modifications which, however, need not concern us in this discussion.

We are inclined to adopt the theory of automaticity of central discharge, but how shall we explain the characteristics of the patterns? Are they a product of the architectural arrangement of the centers or of the periodic sensory bombardments accompanying each respiratory act? Respiratory potentials obtained during curari paralysis, which eliminates periodic afferent signals, show only the slowly augmenting and the steady state patterns indicating their dependence upon architectural structure. The rapidly augmenting pattern is regarded as a reflex modification of the steady state pattern.

These conclusions bring us to the fundamental aspects of nerve cell discharge, upon which we must now build. As early as 1926, we proposed an electrochemical theory of automatic firing of nerve cells. It was based on the far-reaching findings of Child on electrical gradients and on the astounding effects of such gradients upon the iron nerve model of Lillie. According to our theory, a constant current, self-engendered in the cell, flows through the cell body, out of it and back in again through the immediate environment (see Fig. 5). At the point of emergence, the neuromembrane alternately breaks down and rebuilds, producing periodic activation and recovery, thus mimicking the phenomena so easily seen in the iron nerve model. This view is now modified and expanded to explain the phenomenon of motor integration, for our hypothesis looks upon the electrotonic current as the master tool of integration. Not only is it thought to generate signals in purely motor centers, but it is believed to be the source of rhythmical firing wherever it occurs, including all sensory receptors. It is the means of transport of electrical disturbances wherever they arise. This hypothesis rests upon substantial biological support, as exemplified in the work of Romanes, Pfluger, Garten, Child, Lillie, Osterhout and Hill, Adrian, Gasser, Hoagland and others.

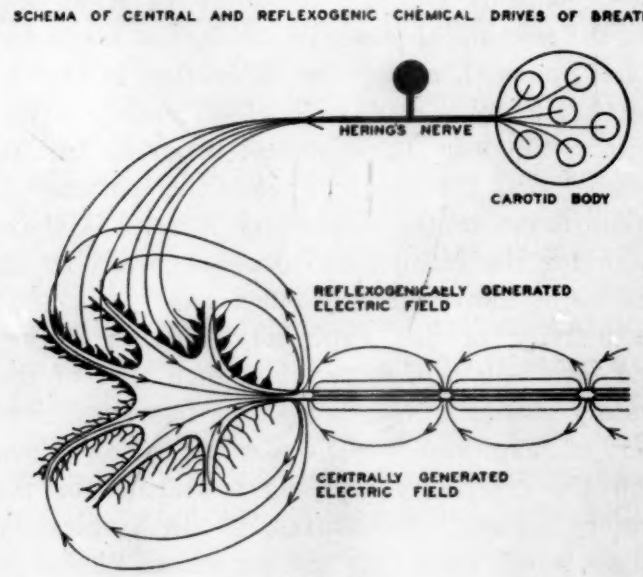

SCHEMA OF CENTRAL AND REFLEXOGENIC CHEMICAL DRIVES OF BREATHING
HERING'S NERVE
CAROTID BODY
REFLEXOGENICALLY GENERATED ELECTRIC FIELD
CENTRALLY GENERATED ELECTRIC FIELD

FIG. 5

Granting self-excitation by a self-engendered electrotonic current we may in turn expect a direct proportionality between frequency of discharge and the magnitude of the electronic current as a physiological mechanism of control such as established by Lillie for the iron nerve. What, then, is a possible automatic mechanism of adjustment of neuro-cellular potential drop? Accepting the views of Craigie, Holmes, Dunning and Wolf, and Gerard, of a high cellular metabolism, as compared with that of the neuraxon, we may assume a strong electrotonic current emerging at the axon hillock. Holmes places the metabolic ratio at 10 to 1. If these metabolic rates are now doubled by a rise of temperature, the metabolic gradient increases form 9 to 18 and theoretically doubles the rate of firing of the axon hillock, thus offering a hypothetical explanation of the hyperpnea of hyperthermia. It is suggested that excess of CO_2 and lack of O_2 adjust the potential drop by the process of selective membrane depolarization at the dendrites and cell body.

Chemical reflexogenic control of nerve cell firing originates in the chemoceptors of the carotid body. The ultimate similarity of the basic mechanism of reflex and central chemical drive of breathing is indicated in our combined schema of centrally and reflexogenically generated electric fields. Central drive is shown in the lower half of the schema and reflex drive in the upper. We propose that each afferent signal impinging at the neuron membrane produces a condition of local negativity which increases the prevailing potential drop in proportion to the number of impinging afferent signals. Numerical variation of afferent drive would accordingly function as a reflexogenic chemical control of breathing.

Believing that neurocellular excitation may be caused by an increased neurocellular potential drop, we propose that inhibition may resolve itself into a decreased potential drop, for example, inhibitory signals impinging on the neuron membrane, in a region below the electrical equator, say, in the proximity of the axon hillock, would reduce the potential drop. The emerging electrotonic current would be opposed, and the frequency of firing would diminish. On this basis, excitation and inhibition are fundamentally the same. We have accordingly connected all supposedly excitatory fibers with the excitatory poles of the reticular cells. Supposedly inhibitory fibers have been connected with the inhibitory poles (see Fig. 6).

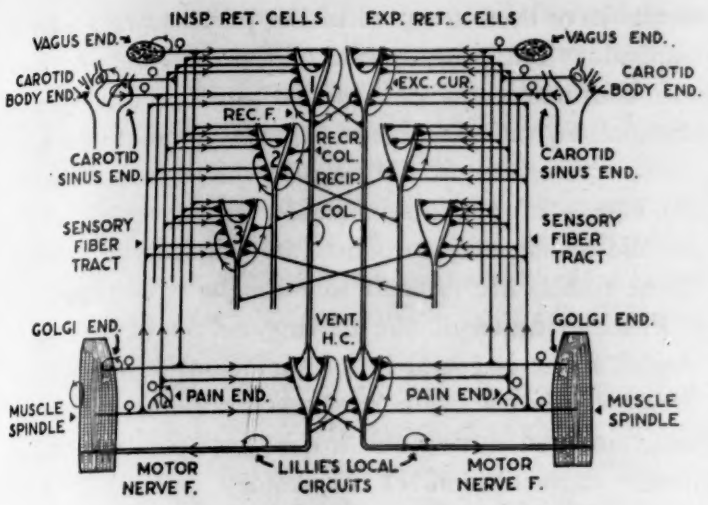


FIG. 6

So much for the basic chemical drives. They are continuous and steady and, therefore, by themselves should produce a steady and continuous firing of the reticular cells, yet the respiratory mechanism responds with periodic discharges. Here we have turned to the concepts of Gasser in building our hypothesis of motor integration, for he has shown a mechanism by which the phrenic nerve is made to respond in a rhythmical way to a uniform train of shocks. We may now consider the production of a periodic response to the steady chemical drives. The phenomena of acceleration and recruitment seem to be important.

We propose that recurrent collaterals offer a simple mechanism of acceleration. The nerve cell need only tap its own neuraxon stream of signals and lead them back to the excitatory pole which gave them birth, to increase the electrical negativity of the excitatory pole and, therefore, the potential drop. This speeds the discharges at the axon hillock, which now return with augmented force to increase the electrotonic drive still more. This progressively and repetitively increasing effect can not continue indefinitely, for progressively increasing activity lowers the ability of the cell body to meet repairs. Growing fatigue gives rise to a disproportionate increase of the threshold of excitation. The re-excitation component which has been built to high values, therefore, suddenly weakens and the fatigued cell stops firing. During inactivity, normal excitability returns and the cell responds once more to its electronic current and passes through the acceleration cycle just described.

Accelerated firing is but the smaller part of each periodic increase of muscle power in the slowly augmenting type of contraction. Recruitment of additional elements, in our experience, is the more important. Though individual phenomena, acceleration and recruitment are inseparable, for acceleration of one reticular cell may be the deciding factor for the recruitment of another. What, then, is a simple mechanism of recruitment? We suggest that the purely motor connections of one reticular cell with the other (Retzius and Lenossek) supply the structural requirements. It is accordingly assumed that highly sensitive reticular cells at the head of the reticular column act as pacesetters for the group. A periodic stream of signals once started, let us say in the pace setter cell No. 1, travels in its reticulospinal neuraxon to its anterior horn cells. On its way, this stream is tapped by collaterals which carry signals to cell No. 2, which is still quiescent, but near the threshold of excitation. Cell No. 2 then fires and sets off cell No. 3. Recruitment continues down the reticular column until cell No. 1 ceases to fire. Absence of signals from cell No. 1 brings cell No. 2 to rest. Cell No. 3 follows suit. Decruitment is more rapid than recruitment, as might be expected from the sudden falling off of cell No. 1. These are our theoretical explanation of the rhythmical recurrence of inspiratory activity.

We must now explain the steady state discharges on the expiratory side. This pattern of activity needs neither the recurrent accelerating collaterals nor recruiting collaterals. Without these mechanisms of periodic augmentation and interruption, the reticular cells theoretically should fire uniformly and indefinitely under a steady drive as they do.

Since both inspiratory and expiratory reticular cells are subject to continuing central and reflex chemical drives, how do they contrive to alternate in activity? Our hypothesis of reciprocal interaction is this. Pacesetting cell No. 1 on the inspiratory side leads off. Collateral signals go to the inhibitory pole of its expiratory mate, which at that moment is still active. These signals inhibit the expiratory cell and slow its discharge. As inspiration waxes the inhibitory action on the opposing cell increases and stops its firing completely, but the expiratory cells are also supposedly connected by collaterals to the inhibitory poles of their inspiratory mates. As the expiratory cell is inhibited and slowed, it withdraws its restraint on inspiratory cell No. 1. This is tantamount to excitation, for the effects of a potential drop in the inspiratory cell are the same, whether the inhibitory pole turns less negative or the excitatory pole more negative. Inspiratory cells thus draw their own excitation from their opposing cells.

We may now return more specifically to the role of sensory impulses in motor integration. We believe that both the inspiratory and expiratory reticular cells possess continuous inherent electrochemical drives and that both are driven by continuous reflexogenic chemical drives as well. When cyanide is injected into the carotid artery to reach the carotid body during the inspiratory phase, it augments the inspiratory act which is in progress. On the other hand, if cyanide is injected during the expiratory phase of breathing, it increases the expiratory contraction which is still

under way. Even though the inspiratory and expiratory reticular cells are under continual bombardment from the outlying chemoceptors, only one group is capable of responding at a time. This single, alternating, selective activation is considered a result of the efficient dual reciprocating mechanism which we have just described. Dual drive (inspiratory and expiratory from a single set of receptors) may be a most important neurophysiological principle, holding not only for the continuing chemical and pain drives but for the periodic drives initiated in the proprioceptive endings of muscle, tendon and lung with each respiratory cycle.

The periodic modification of each respiratory act by transient proprioceptive discharges must now be considered. The vagal nerves which function in a periodic way are generally regarded as inhibitory. According to Hering and Breuer, Gad, Head and Adrian each filling of the lungs stimulates the inhibitory vagal endings and, thereby, inhibits the inspiratory act. After central inhibition wears off a new discharge of the automatically active center occurs. Inspiration is, therefore, prolonged when the vagi are blocked. Virtually all workers disregarded or overlooked the significance of expiration. This point of view is illustrated by a quotation of Adrian's. He states: "An explanation along these lines (*i.e.*, inspiratory inhibition) was in fact given in the classical paper of Henry Head from Hering's laboratory, though it appeared then that the expiratory endings might play some part in the effect." Had physiologists been more reluctant to abandon the expiratory reflexes which Hering and Breuer so clearly demonstrated by inflation of the lungs and had physiologists given more attention to the accelerating action of the vagi on the velocity of the inspiratory act itself rather than the frequency of breathing, the inhibitory theory of vagal function might not have gained the prominence it has to-day.

We shall now consider the vagal stretch reflex as an excitatory drive and determine whether this view meets the facts of vagal physiology. Compare, for example, the velocity of three inspirations in the same dog under three intensities of vagal reflex drive. First, under zero vagal drive with the vagi blocked, second, during normal eupneic breathing, and third, with the lungs superinflated. The velocity is lowest during vagal block, greatest during superinflation and intermediate during eupnea. Comparable though not as uniform effects have been noted in the expiratory gradients, tentatively indicating the possibility of a normal expiratory drive as well.

If the central end of the vagus nerve is subjected to intermittent blocks of faradic stimulation, breathing is stopped as it is by continuous stimulation. Such results have been accepted in the past as proof of the inspiratory inhibitory action of the vagi, but if a second continuous drive is added to this intermittent stimulation, such as central stimulation of the saphenous nerve or chemical stimulation of the carotid body, the effects of vagal stimulation are reversed. Each faradic block may produce an inspiration instead. These results are difficult to reconcile with inhibition.

Final evidence of the driving action of the vagal stretch reflex is found in an augmentation of inspiratory potentials above normal when the lungs are artificially inflated during the inspiratory phase, and frequent augmentation of expiratory potentials when pressure is applied during the expiratory pause. This leads to the more logical interpretation that the vagus is an excitatory nerve and that it may possibly exert a dual drive, one to the inspiratory muscles and the other to the expiratory muscles, in a manner similar to the chemoceptors and nociceptors. The action differs, however, in one important respect, for the signals impinge upon the centers in periodic showers, increasing with each inspiratory inflation and fading away with each expiratory deflation. This waxing of each inspiratory vagal discharge exerts a most effective reinforcement of the slowly augmenting inherent discharge of the center, for as the resistance to inspiration increases the center is automatically driven to fire more intensely. Thus vagal action bolsters inspiration in direct proportion to the degree of pulmonary inflation. When breathing suddenly shifts to the expiratory phase, the vagal drive is suddenly transferred to the expiratory muscles. Vagal expiratory drive is, therefore, at its maximum at the onset of expiration and at its minimum at the close of expiration when the lungs are emptied. We see in this relation a possible reflexogenic mechanism of changing the basic steady state contraction into the rapidly augmenting type, for as vagal drive subsides expiratory contraction diminishes.

Finally, we wish to propose why prolonged artificial inflation of the lungs produces slowing or stoppage of breathing. There are reasons for believing that it may provoke a prolonged reflex tonic discharge of the expiratory reticular cells. These cells in turn are thought to exert an equivalent inhibition of the inspiratory reticular cells via the reciprocating collaterals. This inhibition continues until it is overcome by the accumulating chemical drives of the resulting asphyxia which act more powerfully on the inspiratory side. Only when that moment arrives does inspiration start once more. Such explanation of inspiratory inhibition would call for a fundamental re-analysis of so-called reflex inhibition in all motor integrations.

Little is known of the function of the Golgi endings.

Fulton and Pi Suner regard them as tension receptors. Since the tension of the inspiratory muscles increases as they meet with increasing resistance during inspiration, the signals which the Golgi endings send out must increase, as do those of the vagal endings. We, therefore, propose that Golgi signals bolster the inspiratory act as do the vagal signals. This effect is readily demonstrated in the augmentation of action potentials of an inspiratory muscle by occlusion of the trachea during inspiration.

Still less is known about the muscle spindles. Fulton and Pi Suner and Matthews point to the significant fact that these sensory end organs are arranged in parallel with the contractile fibers. They, therefore, suggest that the spindles are released of their strain when shortening of the muscle occurs. In this mechanical arrangement we see the possibility of another automatic mechanism of reflex bolstering of contraction, for if the muscle spindles are inhibitory the inhibition which they produce would diminish as contraction progresses.

In conclusion, we may say that though we have attempted to analyze only the forces which drive the respiratory act, the principles outlined may be basic to a fundamental concept of the integration of motor activity in general.

SCIENTIFIC EVENTS

THE BEIT MEMORIAL FELLOWSHIPS

A MEETING of the trustees of the Beit Memorial Fellowships for Medical Research, at which Sir Alfred Beit, Lord Onslow, Lord Harlech, Lord Rayleigh, Lord Macmillan, Professor T. R. Elliott and Dr. H. L. Eason were present, was held in London on July 19. According to the London *Times* resignations from the advisory board of Sir F. Gowland Hopkins and Sir Patrick Laidlaw were received and the vacancies were filled by the appointment of Dr. R. A. Peters, Whitley professor of biochemistry, University of Oxford, and of Dr. Paul Fildes, bacteriologist on the scientific staff of the Medical Research Council.

The following elections to fellowships were made:

Fourth Year Fellowships (value £500 a year).—Isaac Berenblum, M.D., M.Sc. (London). To continue his work on the production of cancer by skin irritants, and to study the metabolism of living cells in tissue culture. At the School of Pathology, University of Oxford.

Thomas Arthur Howard Munro, M.B., Ch.B., F.R.C.P. (Edinburgh). To continue his studies of the rôle of inheritance in mental disorders. At the Royal Eastern Counties Institution, Colchester.

Albert Neuberger, M.D. (Wurzburg), Ph.D. (London). To extend his work on the chemistry of amino sugars in elucidation of the structure of natural compounds. At the department of pathological chemistry, University College Hospital Medical School, University of London.

Richard Julius Pumphrey, M.A., Ph.D. (Cambridge). To continue his studies on the nervous system of Cephalopods and on the auditory processes in insects. At the zoological laboratory, University of Cambridge, and the laboratory of the Marine Biological Association, Plymouth.

Junior Fellowships (value £400 a year).—Vernon Hollis Booth, B.A., Ph.D. (Cambridge). George Henry Lewes Student, 1935–38. Ramsay Memorial fellow for chemical research, 1938–39. Proposed research—(1) the internal constituents of bacteria by means of a wet-crushing mill; (2) carbonic anhydrase. At the physiological laboratory, University of Cambridge.

Eric George Lapthorne Bywaters, M.B., B.S., Hons. (London), M.R.C.P. Assistant clinical pathologist, Middlesex Hospital, 1935–36; Rockefeller research fellow in medicine, 1937–38. Proposed research—rheumatoid arthritis. At the British Post-Graduate Medical School, University of London.

Wilfred Ingram Card, M.D. (London), M.R.C.P. Since 1935 medical registrar and tutor to the medical unit, St. Thomas's Hospital; Louis Jenner research fellow, St. Thomas's Hospital, 1938 and 1939. Proposed research—the inhibition of gastric motility and secretion by experimental studies on man. At the medical unit laboratories and Sherrington School of Physiology, St. Thomas's Hospital Medical School, University of London.

Hans Heller, Ph.D. (Prague), M.B., B.Ch. (Cambridge). Assistant to professor of pharmacology, University of Vienna, 1929–34. Proposed research—the antidiuretic principle of post-pituitary extract. At the medical unit laboratories, University College Hospital Medical School, University of London.

Maxwell Shaw Jones, M.D. (Edinburgh), D.P.M. (London). Walter Smith Kay research fellow in psychiatry, University of Edinburgh, 1934–36; Commonwealth Fund fellow, 1936–38. Proposed research—insulin treatment of schizophrenic mental states. At the Maudsley Hospital, Denmark Hill, University of London.

Barnett Levin, B.Sc. Hons., Ph.D. (London). Pedler research scholar, Institute of Chemistry, 1931–32. Since 1932 lecturer in chemistry at Guy's Hospital Medical School, University of London. Proposed research—the effect of spatial configuration of antigens on immunological reactions. At the clinical chemical laboratories of the London Hospital, University of London.

Ian Mackenzie, M.B., Ch.B., F.R.C.S. (Edinburgh). Vans Dunlop scholar in bacteriology, University of Edinburgh, 1933. Rockefeller research fellow, 1938. Proposed research—immunological investigations on constituents of tumors. At the department of surgical research, University of Edinburgh.

Alexander Francis Rawdon-Smith, M.A., Ph.D. (Cambridge). Senior student of the 1851 exhibition, 1936–37 and 1938–39. Rockefeller Foundation fellow, 1938. Proposed research—congenital deafness. At the physiological laboratory, University of Cambridge.

Basil Roland Record, B.Sc. Hons., Ph.D. (Birmingham). Department of scientific and industrial research award, 1937–39. Proposed research—the specific soluble substance found in the tissues in acute vaccinial infection. At the Lister Institute of Preventive Medicine, University of London.

NOMINATIONS TO THE COUNCIL OF THE AMERICAN ASSOCIATION OF MUSEUMS

NOMINATIONS to the Council of the American Association of Museums for the three-year term of 1940–43 have been made by the council as follows:

Clyde H. Burroughs, secretary of the Detroit Institute of Arts.

Frederick Trubee Davison, president of the American Museum of Natural History, New York.

Mrs. Juliana R. Force, director of the Whitney Museum of American Art, New York.

James J. A. Fortier, president of the Louisiana State Museum, New Orleans.

Chauncey J. Hamlin, president of the Buffalo Society of Natural Sciences; a former president of the American Association of Museums.

Robert T. Hatt, director of the Cranbrook Institute of Science, Bloomfield Hills.

Horace H. F. Jayne, director of the University Museum, University of Pennsylvania.

Miss Mildred E. Manter, director of the Children's Museum, Boston.

Daniel Catton Rich, director of the Art Institute of Chicago.

Francis Henry Taylor, director of the Worcester Art Museum.

The by-laws provide that any five members of the association may make other nominations in writing. Additional nominations reaching the office of the association before April 12 will be incorporated in the final ticket. The council's nominations and any additional nominations that may be put forward by members will be voted on by mail prior to the annual meeting, which begins on May 22. Council members elected will take office at the time of the annual meeting.

SYMPOSIUM ON THE THERMODYNAMICS OF HYDROCARBONS

THE American Chemical Society will hold a national symposium on "Fundamental Thermodynamics of Hydrocarbons and Their Derivatives" at its ninety-ninth meeting, which will be held in Cincinnati from April 8 to 12.

The symposium, of which Dr. Frederick D. Rossini, chief of the Section of Thermochemistry and Constitution of Petroleum of the National Bureau of Standards, Washington, D. C., will be chairman, is planned to give fresh direction to the new and revolutionary activities of the petroleum industry in the potentially vast field of synthetic products, including plastics, artificial rubber and silk and other materials.

While the petroleum industry, with a $2,000,000,000 investment in refineries, is now primarily concerned with the production of fuels for automobiles and airplanes, it is also believed to be at the threshold of practically limitless expansion as a manufacturer of synthetics. Chemists aim to clarify the scientific and economic problems involved in this development.

The purpose of the symposium is to bring before scientific men and technologists associated with the petroleum and other allied industries a summary of present knowledge concerning the thermodynamic properties of hydrocarbons and related compounds. With this summary available, it will be possible to know what new thermodynamic data need to be obtained in some cases because of the absence of any data at all and in others because many of the older data are not accurate enough to satisfy present-day requirements.

Speakers at the symposium will include: Professor E. Bright Wilson, Jr., of Harvard University, who won the $1,000 American Chemical Society Award in Pure Science in 1937 for experimental work in physical chemistry; Professor John G. Aston, of Pennsylvania State College; Professor Kenneth S. Pitzer, of the University of California; Professor George S. Parks, of Stanford University, and Dr. Rossini.

The symposium will be a feature of the program of the Division of Petroleum Chemistry, of which Dr. Cary R. Wagner, of the Pure Oil Company, Chicago, is chairman.

PIONEERS ON THE AMERICAN FRONTIERS OF INDUSTRY

ON the occasion of the hundred and fiftieth anniversary of the founding of the American patent system a series of fourteen regional meetings and dinners were held throughout the country during February under the auspices of the American Manufacturers Association. At these dinners, sponsored by state industrial groups, scrolls were awarded to about five hundred local "Modern Pioneers on the American Frontiers of Industry" for "significant contributions to the creation of jobs and the improvement of the standard of living through patented inventions or discoveries."

Robert L. Lund, executive vice-president of the Lambert Pharmacal Company, was chairman of the national committee. Members of the committee on awards were:

Karl T. Compton, president, Massachusetts Institute of Technology; past president, American Association for the Advancement of Science, *chairman*.

Forest R. Moulton, permanent secretary, American Asso-

ciation for the Advancement of Science; formerly professor of astronomy, University of Chicago.

George B. Pegram, dean, Graduate Faculties of Columbia University; past president, Society for Promotion of Engineering Education.

John T. Tate, dean, College of Science, Literature and the Arts of the University of Minnesota; president, American Physical Society.

Edward R. Weidlein, director, Mellon Institute; past president, American Institute of Chemical Engineers.

Frank C. Whitmore, dean, School of Chemistry and Physics of Pennsylvania State College; past president, American Chemical Society.

Those "Modern Pioneers" whose contributions were regarded by the Committee on Awards as particularly significant were honored at a final national dinner at the Waldorf Astoria Hotel, New York City, on February 27, when more than fifteen hundred representatives of industry, commerce and government were in attendance. Nineteen leading inventors and research workers judged by the committee to have made outstanding contributions to the progress of the country in the last twenty-five years were honored as national "Modern Pioneers" and were awarded silver plaques. A silver plaque was also awarded to a group of eleven research workers of the du Pont laboratories. Earlier in the evening the hundred and one local inventors selected by the committee from the New York and New Jersey area were awarded scrolls.

H. W. Prentis, Jr., of Lancaster, Pa., president of the National Association of Manufacturers, was the principal speaker at the dinner. Other speakers were Dr. Compton, Mr. Lund and Conway P. Coe, Commissioner of Patents. Dr. Charles F. Kettering, vice-president of the General Motors Corporation, addressed the gathering by telephone from his laboratory at Coral Gables, Florida.

Those who received silver plaques are:

Dr. Edwin Howard Armstrong, professor of electrical engineering at Columbia University.

Dr. Leo Hendrik Baekeland, founder and retired president of the Bakelite Corporation of New York.

Dr. William Meriam Burton, of Pasadena, Calif., a former president of the Standard Oil Company of Indiana.

Willis Haviland Carrier, chairman of the board of the Carrier Corporation of Syracuse.

Dr. William David Coolidge, director of the research laboratory of the General Electric Company, Schenectady.

Dr. Frederick Gardner Cottrell, chemist, of Washington.

Dr. George Oliver Curme, Jr., vice-president of the Carbide and Carbon Chemicals Corporation of New York.

Dr. Lee De Forest, president of several De Forest companies, Hollywood, Calif.

John Van Nostrand Dorr, president of Dorr Company, Inc., New York.

Henry Ford, president of the Ford Motor Company, Dearborn, Mich.

Dr. Charles Franklin Kettering, president of General Motors Research Corporation and vice-president of General Motors Corporation.

Edwin Herbert Land, president of the Polaroid Corporation, Boston.

Dr. Irving Langmuir, associate director of the research laboratory of the General Electric Company.

Dr. Harry Steenbock, professor of biochemistry at the University of Wisconsin.

John B. Tytus, vice-president in charge of operations of the American Rolling Mills Company, Middletown, Ohio.

Charles Frederick Wallace, vice-president of Wallace & Tiernan Company, Inc., Belleville, N. J.

Orville Wright, of Dayton, Ohio.

Dr. Vladimir Kosma Zworykin, research engineer of R.-C.-A. Manufacturing Company, Camden, N. J.

The following Nylon group from E. I. du Pont de Nemours & Co., Wilmington, Del.: Drs. Williard E. Catlin, Donald D. Coffman, Winfield W. Heckert, Benjamin W. Howk, George D. Graves, Wilbur A. Lazier, John B. Miles, Jr., Wesley R. Peterson, Frank K. Signaigo, Edgar W. Spanagel and the late Wallace Hume Carothers.

RECENT DEATHS

ARTHUR EDWIN NORTON, since 1935 Gordon McKay professor of applied mechanics in the School of Engineering of Harvard University, died suddenly on February 24. He was in his sixty-third year.

DR. JOSHUA WILLIAM BEEDE, instructor and professor of geology at Indiana University from 1901 to 1917 and from 1928 to 1930, died on February 27 at the age of sixty-eight years. Professor Beede was geologist of the Texas Geological Survey from 1917 to 1922 and was the author of numerous papers on the Upper Paleozoic rocks of Kansas, Oklahoma and Texas.

DR. ORAN RABER, plant physiologist and conservationist in the U. S. Forest Service at New Orleans, died on February 29 at the age of forty-seven years.

MAURICE BLUMENTHAL, consulting engineer of Brooklyn, N. Y., died on February 27 at the age of fifty-two years.

PROFESSOR ALEXANDRE BESREDKA, chief of the laboratory of the Pasteur Institute, Paris, died on February 28. He was seventy years old.

Nature announces the death of Professor Aristide Busi, director of the Institute of Medical Radiology, Rome, aged sixty-five years; of W. M. Gardner, principal of Bradford Technical College from 1905 to 1921, on December 22, aged seventy-eight years; of W. H. Lovegrove, formerly conservator of forests, Kashmir, on January 25, aged seventy-two years; of Professor S. Lees, Chance professor of mechanical engineering in the University of Birmingham, aged

fifty-four years; of B. D. Porritt, director of research of the Research Association of Rubber Manufacturers, on January 28, aged fifty-six years; of F. T. Shutt, formerly Chief Dominion Chemist and assistant director of the Central Experimental Farm, aged eighty years.

SCIENTIFIC NOTES AND NEWS

VOLUME 66 of *The Journal of Morphology,* appearing during the first half of the year 1940, is being published in honor of Dr. C. E. McClung, professor of zoology at the University of Pennsylvania, whose seventieth birthday occurs on April 5. He has been managing editor of the journal since 1920. It will consist primarily of papers by his former students. It will also include a recent photograph of Dr. McClung, a salutatory statement by Dr. Frank R. Lillie, a biographical sketch and a bibliography of his publications.

THE William H. Nichols Medal of the New York Section of the American Chemical Society was presented to Professor John M. Nelson, of Columbia University, at a dinner of the section at the Hotel Pennsylvania on March 8. The medal was awarded to him in recognition of "important contributions to the chemistry of life processes."

DR. JOHN HERR MUSSER, professor of medicine at Tulane University, received the Alumni Award of Merit of the School of Medicine of the University of Pennsylvania on Founder's Day, January 17, as part of the observance of the bicentennial of the university.

THE Royal Society, London, has conferred foreign membership on Dr. Paul Langevin, professor of physics at the Collège de France and director of the École de Physique et de Chimie, Paris, who was a member of the recent delegation of scientific men sent from France to Great Britain to arrange for a liaison between the scientific organizations of the two countries.

CORRESPONDING members of the Geological Society of America were elected at the Columbus meeting as follows: Per A. Geijer and Erik H. O. Stensiö, of Stockholm, and Felix Andries Vening Meinesz, of Utrecht.

THE German Goethe Medal has been awarded to Dr. Paul Uhlenhuth, professor of hygiene and bacteriology at Freiburg/Br.

THE Harben Gold Medal of the Royal Institute of Public Health and Hygiene, London, has been awarded to Sir Leonard Hill, professor of physiology at the Hospital of the University of London. The Smith award has been conferred on Sir William Savage, recently medical officer of health, Somerset.

RECENTLY elected officers of the Society of Economic Paleontologists and Mineralogists are: *President,* Professor Carey Croneis, University of Chicago; *Vice-president* Dr. J. R. Sandidge, Magnolia Petroleum Corporation; *Secretary-Treasurer,* Dr. H. B. Stenzel, Texas Bureau of Economic Geology; *Councillors,* Past-presidents Professor Gayle Scott, Texas Christian University, and Dr. E. H. Sellards, director of the Texas Bureau of Economic Geology. Professors Norman D. Newell and W. H. Twenhofel, of the University of Wisconsin, continue as editors, respectively, of the periodicals of the society, the *Journal of Paleontology* and the *Journal of Sedimentary Petrology.*

DR. ARTHUR B. LAMB, professor of chemistry and director of the chemical laboratory of Harvard University, has been appointed dean of the Graduate School of Arts and Sciences. Dr. Lamb was professor of chemistry and director of the Havemeyer Laboratory of New York University until 1912, when he took up the work at Harvard University.

DR. STANLEY E. DORST, associate professor of medicine and assistant dean of the College of Medicine of the University of Cincinnati, has been appointed dean to succeed the late Dr. Alfred Friedlander.

BERTRAND RUSSELL, the British mathematician and philosopher, has been appointed professor of philosophy at the College of the City of New York, and Dr. Alfred Tarski, formerly of the University of Warsaw, visiting professor of philosophy. Dr. Gardner Murphy, assistant professor at Columbia University, has been appointed professor of psychology. The appointments are to fill vacancies caused by the recent retirement of Professor Harry Allen Overstreet and of Dr. Morris Raphael Cohen. The department of philosophy and psychology has been divided into two departments.

DR. ALFRED K. SNELGROVE, secretary of the department of geology at Princeton University and of the Princeton Geological Association, has been appointed head of the department of geology and mineralogy at the Michigan College of Mining and Technology.

EDWARD GEORGE TANDY LIDDELL, fellow of Trinity College, Oxford, has been appointed from March 1 Waynflete professor of physiology at the University of Oxford.

DR. F. WOOD JONES, of the University of Manchester, has withdrawn his resignation from the chair of anatomy, which was to have taken effect on Decem-

ber 25. Dr. J. C. Dundon has been appointed demonstrator in anatomy.

PROFESSOR FRITZ LEJEUNE, of Cologne, has been appointed professor of the history of medicine and director of the Institute of the History of Medicine at Vienna.

DR. ROBERT K. BURNS, JR., associate professor of anatomy at the School of Medicine and Dentistry of the University of Rochester, has accepted appointment as a member of the staff of the Carnegie Institution of Washington in the department of embryology in Baltimore. The appointment becomes effective on July 1.

DR. JESSE T. LITTLETON, who has for the past twenty years been at the head of the laboratory of physics of the Corning Glass Works at Corning, N. Y., has been appointed to the newly established position of assistant director of research. He has been a member of the staff since 1913.

DR. WILLIAM L. STRUNK, head of the Student Health Service at St. Olaf College, Northfield, Minn., has been appointed conservation commissioner for the State of Minnesota. Dr. Strunk took up this work on February 1, with leave of absence from St. Olaf College.

The editorial board of the journal *Growth*, together with the council and officers, have been replaced by a general board of editors, with the addition of eight new members, to make a group of twenty-five, as follows: John Berrill, S. Brody, H. S. Burr, S. A. Courtis, C. H. Danforth, Chas. B. Davenport, L. K. Frank, P. W. Gregory, F. S. Hammett, Leigh Hoadley, Clyde Kluckholn, Warren H. Lewis, Leo Loeb, Carroll E. Palmer, Otto Rahn, H. S. Reed, S. P. Reimann, R. E. Scammon, E. W. Sinnott, K. V. Thimann, Paul Weiss, Philip R. White, D. M. Whitaker, B. H. Willier, Sewall Wright. All inquiries, manuscripts and subscriptions should be addressed to the Editors of *Growth*, Dairy Building, Cornell University, Ithaca, N. Y.

DR. D. J. STEPHENS, of the School of Medicine and Dentistry of the University of Rochester, N. Y., has been awarded a grant by the Committee on Scientific Research of the American Medical Association for the continuation of a study of the effects of undernutrition on the thyroid and ovary of the guinea pig.

DR. JAMES BRYANT CONANT, president of Harvard University, will be the principal speaker on March 24 at the charter anniversary programs of Founders' Day of the University of California at Los Angeles. On March 28 he will speak at the anniversary ceremony at Berkeley and will also be the speaker at the Charter banquet in the evening.

DR. J. BJERKNES, professor at the Geophysical Institute, Bergen, Norway, was Walker-Ames lecturer in the department of geography of the University of Washington, Seattle, during February. He gave a series of lectures on meteorology, including the polar front theory, pressure variations and the Bjerknes circulation theorem.

THE fifth Leo Loeb lecture under the annual lectureship which has been established by the Mu Chapter of the Phi Beta Pi Medical Fraternity, will be delivered on March 8 at the School of Medicine of Washington University by Dr. Paul R. Cannon, professor of pathology at the University of Chicago. The subject of his address is "Some Aspects of Allergy."

DR. ROBERT CUSHMAN MURPHY, of the American Museum of Natural History, spoke on "Banding as Method and as Influence in Modern Ornithology" at the dinner closing the annual meeting of the Eastern Bird Banding Association, which was held in New York City on February 23, 24 and 25.

IN a note in the issue of SCIENCE for February 23 Dr. Francis W. Reichelderfer was referred to as Lieutenant Commander in the navy and acting chief of the U. S. Weather Bureau. Dr. Reichelderfer was promoted from acting chief to chief of the Weather Bureau on January 2, 1939. He was promoted from Lieutenant Commander to Commander in the United States Navy in 1938. On his appointment as chief of the Weather Bureau he was placed on the inactive list of the Navy.

IT is proposed that the position of permanent scientific attaché be established at the French Embassy in London to promote the interchange of scientific information between France and England.

APPLICATIONS must be on file with the U. S. Civil Service Commission at Washington, D. C., not later than March 25 for the office of chief of research and statistical service of the Office of Education, Federal Security Agency, at a salary of $5,600 a year.

THE Federation of American Societies for Experimental Biology, which is composed of the American Physiological Society, the American Society of Biological Chemists, the American Society for Pharmacology and Experimental Therapeutics and the American Society for Experimental Pathology, will meet in New Orleans on March 13, 14, 15 and 16. The Roosevelt Hotel will serve as headquarters and all scientific sessions and demonstrations, including the joint sessions, will be held in the Municipal Auditorium.

MEMBERS of Section F (Zoological Sciences) who desire to present papers at the Seattle meeting of the American Association for the Advancement of Science

should send titles and abstracts before May 1 to Professor James E. Lynch, School of Fisheries, University of Washington, Seattle, Washington.

THE School of Forestry of Yale University celebrated its fortieth anniversary on February 23. The speakers included Gifford Pinchot, formerly governor of Pennsylvania, and Henry S. Graves, dean emeritus, both members of the original faculty of the school. Other speakers were Professor H. H. Chapman, Professor G. A. Garratt, Dean Samuel J. Record, of the School of Forestry; Dean Charles H. Warren, of the Sheffield Scientific School; Austin F. Hawes, state forester of Connecticut and president of the School of Forestry Alumni Association, and Samuel T. Dana, a member of the class of '07 and dean of the School of Forestry and Conservation of the University of Michigan. Samuel N. Spring, dean of the New York State College of Forestry, was toastmaster at a dinner at the New Haven Lawn Club in the evening. The principal speaker was Dr. James Rowland Angell, president emeritus of the university.

AT Kansas State College a department of chemical engineering has been organized with Dr. W. L. Faith as head. The personnel and equipment, hitherto included in the department of chemistry, have been transferred to the Division of Engineering and Architecture and are housed in a remodeled building formerly used by the department of dairy husbandry.

A BOARD of inquiry for the Great Lakes Fisheries was established on February 9 by Canada and the United States through an exchange of notes for the purpose of making a study and recommending methods of preserving and developing the fisheries. It will hold hearings in the Great Lakes area for that purpose. The American members of the board are Hubert R. Gallagher, of Chicago, assistant director of the Council of State Governments, and Dr. John R. van Oosten, of Ann Arbor, who is in charge of Great Lakes fisheries investigations for the U. S. Bureau of Fisheries. The Canadian members are Professor A. G. Huntsman, consulting director of the Biological Board of Canada, and D. J. Taylor, deputy minister of the Department of Game and Fisheries of Ontario.

Nature states that the Bureau of Human Heredity, London, is carrying on, with reduced activity, durin the war. Although the bureau has lost several work ers, it has enlisted the support of Professor F. A. E Crew as honorary medical secretary. Correspondenc with men of science in other countries continues, bu in diminished volume, which may give time for other projects, including (1) surveys of the genetic back ground in tuberculosis, (2) the human analogue of th transmission of cancer in animals, (3) certain im munological problems. It is hoped also to compile a preliminary list of inherited disorders and defec based on recent research for the use of practitioner and teachers. The address of the bureau is 115 Gow Street, London, W.C.1.

A GIFT of $42,200 has been made to the Tufts Co lege Medical School by Dr. and Mrs. George G. Averi of Waterville, Maine. The fund, to be turned over t the school during the years of 1940 and 1941, will b devoted to the establishment of the "Dr. and Mr George G. Averill Department of Anatomy in memor of Professor Charles P. Thayer." Known as an in dustrialist, Dr. Averill was one of the first physician graduated from Tufts College Medical School near a half-century ago. The new Medical School Building of which the gift will provide the entire top floor, wi be situated in downtown Boston at the New Englan Medical Center, convenient to the Boston City Ho pital and the other clinical teaching centers. It wi be erected as soon as the entire $750,000 needed ha been obtained. Dr. Charles P. Thayer, in whos memory the gift was made, was one of the "origina seven" founders of the school in 1893 and the fir head of the department of anatomy. A fund fo dermatological research has also been established b the Ernest Bischoff Company, Inc., of Ivoryto Conn., manufacturers of pharmaceuticals.

THE important entomological collections, manu scripts, etc., bequeathed by the late William Mill Christy, have been received at the British Museu (Natural History). There are 21,312 specimens o British Lepidoptera, many specimens which are add tions to the existing British collection. Mrs. Brow low, who inherited the collections, has also presente to the museum a number of important entomologic books from Mr. Christy's library.

DISCUSSION

SCIENCE IN CHINA

A LETTER has recently come from a former student of mine, Dr. Pei-sung Tang, now working at Kunming, China, addressed to a number of scientists in this country with whom Dr. Tang worked. It has been suggested that the letter might be of general interest, showing, as it does, the indomitable spirit which animates the scientific workers of China in their present tragic situation. A selection of those portions whi seem appropriate is here presented.

WILLIAM S. COOPER
UNIVERSITY OF MINNESOTA

TSING HUA UNIVERSITY, KUNMING, YUNNAN PROV., CHINA, AUG. 16, '39

If you will look into the map of China, I am at t present hiding in the farthest corner from the war. I l Wuchang soon after the fall of Nanking, and destro

e furnace and machine works with which we had been aking gas masks there. The masks were only very imitive affairs so that I am glad the Japs did not force to use them. For a while we were in a loss of what do, for it looked as though the Japs were at our heels, d everything was in turmoil. At this time there was tablished in the interior of China, at Kweiyang, a medi- l school for the training of physicians who were to be nt to the front. I was asked to be on the scientific staff, d be responsible for the preclinical courses, and to tablish laboratories. This I took up, and went through l kinds of hardships to get there. You may never be le to imagine what we went through: 16 days on the owded deck of an overloaded steamer on the treacherous angtze during the coldest part of the year. Up the pids the boats had to be pulled by man power or eam capstan, and several times the cable broke, and it s only by the best of good fortune that we escaped ath. There was standing room only on deck, and at ght we did the best we could to get some sleep, with thes on. Two days of motoring on staircase highways Kweiyang—with robbery and road accidents to make trip colorful, and sleeping in vermin-infested beds xt to pig pens and cattle.

Six months in Kweiyang to start a medical school from thing—absolutely nothing, except a "hospital" of four ds and a group of determined men. But those months re the happiest of my life. The medical school has en in full swing for over a year, with four terms a year hicago plan—on my suggestion), with a good staff, and w a hospital of over 100 beds. And laboratories which y well compare with any school in China in equipment. d if there is anything more satisfactory to a pioneer, furniture and the laboratory benches of that school a source of joy to me, even when I am away from m. I designed everything, from a three-legged stool fter the principle of the tripod, for the floors are un- n) to the actually hand-made pneumothorax machine ich was rigged up from parts gotten from junk shops by myself, in order that a very serious case of tuber- osis might be treated. And since then that machine, de as it may be, has served over 200 patients.

Went to Hongkong for two months to buy equipment the college, and in doing so, I traveled all over the thwest of China on bus, pushing the bus most of the e; and sometimes in the dark, when no lights were ilable, I had two hand-torches in my hands and ran ore the bus so that we might reach the city for the ht.

Now that the medical school was going on prosperously, ecided to do something useful again. At the invitation the president of Tsing Hua, my alma mater, I came to nming to establish a laboratory of plant physiology he Institute of Agricultural Researeh. I hope you will blame me for being a coward retreating to the rear, the fight from now on is not in actual warfare, but economic affairs. Already the Japs are trying to drain nd choke us from a financial standpoint. It is our aim to prepare for a prolonged blockade. This is per- s more deadly than the killing of a few thousand men, he taking of a few cities. We are trying to exploit our native materials for the industries. For instance, in the last year we have spent a good deal of our "physiological time" in investigations on castor oil. We have succeeded in substituting castor oil for imported mineral oil, and are now working on the substitution of sumac wax for paraffin. Of course we are not so much concerned with whether our biologists have materials for their slides, but are more concerned about candles and shoe polish and vaseline, for which last we have a substitute. I am known in southwest China as the Castor Oil Man now, whether you believe it or not, and in spite of myself.

We are incidentally doing work on plant hormones and on colchicine. We are synthesizing hormones for the rest of the country, and trying to persuade people the use of colchicine in agriculture. You may not believe that we still have time and money to do such things on such a scale, but we actually are doing them, in spite of occasional bombings.

May be with a year or so more of this war, we shall all turn to be cave-dwelling savages because of the aerial attacks of the Japs. But I really do not believe that they can do anything more. Industrial cooperatives are springing up like mushrooms, and handicraft industries are being developed in the interior. You should visit the interior of China to see the utmost ingenuity that we have for our industrial development.

You may be interested to know how the whole population feels towards the war. Well, there is only one answer: the more we fight, the more confident we become, and the more we suffer, and heaven knows we are suffering enough (no milk, not even a decent bath), but the more we suffer, the more determined we are. We play bridge every Saturday night, and have fun looking into the old copies of *Life* and wonder if *Life* is real. Incidentally, any old magazines such as *Life, Look, Click*, are welcome, just as a contrast between our actual life here and abroad. Of course we are missing a great deal—the fine things that science and industry can give us, the music, the arts and the theater, but I can sincerely say that we are having an experience that you all may envy, for as in a foot ball game, we are the players, and you are the spectators. We are the ones that get the real fun. On the other hand, as long as you (in abstract form) give us a hand once in a while and will not let us down, we shall play the game much better. (I am not pleading for help.)

PEI-SUNG TANG

INJURY TO TREES FROM SULFUR DIOXIDE FUMES OF ELECTRIC REFRIGERATORS[1]

ON September 11, 1939, the writers found that plants exposed to gas fumes from a disabled electric refrigerator in a local household showed considerable injury following exposure to sunlight. A report from eastern Massachusetts last year indicated that foliage of trees had wilted suddenly near an electric refrigeration plant which was out of order. Gas fumes were not mentioned in this report, but specimens from the

[1] Contribution Number 358 of the Massachusetts Agricultural Experiment Station.

trees affected showed the characteristic foliage discoloration produced when gas fumes come in contact with leaves.

The Amherst report afforded opportunity to obtain detailed records of injury to trees which resulted from a defective electric refrigerator in an average household. When the gas fumes were detected, the repairman inserted a tube into the refrigerator to facilitate the passage of gas into the open air at the rear door of the house. At this point, in the absence of any strong currents of air, the gas settled upon the vegetation, covering an area of approximately 500 square feet. Leaves of small elm trees showed a marked reaction within twenty-four hours, as did the foliage of a privet hedge, some other shrubs and a large patch of lawn. The foliage of all deciduous plants showed an uneven, brownish, spotty discoloration and distortion. A Colorado blue spruce, almost in the center of the area affected, at first showed very little indication of injury; but within a few days had lost certain reddened needles, mostly from the lower branches. The spread of the gas from the south side of the affected area, where it had been released, to the northeast corner left a trail of injured plants throughout the plot. Observation showed that in the case of plants nearest to the point of gas release, injury was apparent promptly; while, at the northeastern limit of the plot, conspicuous injury to plants did not appear for five days.

After two weeks the appearance of the lawn improved materially, and the brown area, which was at first conspicuous, quickly disappeared as new grass shoots appeared above the burned area. This would indicate that in cases of limited exposure to gas in the atmosphere, satisfactory regeneration of a lawn will result without reseeding. Injury to the other plants did not progress beyond the limited death of leaves and smaller branches. Examination of the latent buds, green tissue of the bark and roots indicated that practically normal growth may be expected on the affected perennials during the next growing season. The transient presence of the gas, sulfur dioxide, in the atmosphere surrounding the plants had resulted in a mild form of the injury which occurs extensively in areas where this gas is abundant in the atmosphere or regularly present in dilute quantities. In the presence of water, this gas behaves as though sulfurous acid (H_2SO_3) were formed and further oxidation gives sulfuric acid (H_2SO_4), which causes spotting of plant foliage in zones where smoke is abundant. The gas injury to plants in Amherst was of the acute type as contrasted with the chronic and possibly invisible types of sulfur dioxide injury which occur under appropriate conditions. Sulfur dioxide injury to plants is not a new plant disease. However, the use of the gas in electric refrigeration offers a possible source for more cases of isolated reports of injured tree foliage which may be limited or serious, depending upon local conditions.

The diagnosis of this type of injury to plants presents certain complications, and one should not conclude hastily that sulfur dioxide has injured plants in any particular instance. Injuries from plant pests, early frost, drought, sun scorch and certain other troubles may be confused with this injury, and only after a detailed study of an area involved, should one decide that the gas fumes from a defective refrigerator have injured plants. The injury to plant foliage caused by gas escaping from defective electric refrigerators as reported here applies only to electric refrigerators which use sulfur dioxide or other gases which are injurious to plant life.

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ANTHELMINTIC INACTIVITY OF FRESH PINEAPPLE JUICE IN VIVO

J. BERGER and C. F. Asenjo published their "Anthelmintic Activity of Fresh Pineapple Juice" in SCIENCE for September 29 (Vol. 90: 299–300), 1939. These authors incubated *Ascaris suum* and *Macracanthocephalus hirudinaceus in vitro* in freshly squeezed pineapple juice in which both parasites were completely digested at the end of 24 hours. The authors have suggested that there is some scientific basis for the use of fresh pineapple juice as an anthelmintic.

The present note is based mainly on observations on living animals.

A puppy, fifteen pounds in weight, infected with *Toxocara canis,* was given 100 cc of fresh pineapple juice every morning for three days. During these days the supper and breakfast were omitted. On the second morning the dog had expelled 13 parasites. This, however, is quite a usual occurrence in the case of infection with *Toxocara.* At autopsy on the fifth day 26 live ascarids were found distributed through the intestinal tract.

A kitten, three pounds in weight, known to be infected with *Toxocara cati,* was given 25–30 cc of fresh pineapple juice every morning for four days. The first two doses were given by mouth, the third and fourth doses were introduced by stomach tube. At autopsy on the fifth day 35 live ascarids were found in the small intestine.

A child infected with pinworms, *Enterobius vermicularis,* has been given fresh pineapple juice every morning for three weeks. The infection still persists.

Observations were also made on *Toxocara canis* and *T. cati in vitro* at 38° C. In fresh pineapple juice these ascarids were almost completely digested in 15 to 20 hours. Pineapple juice added to gastric juice

and to 0.2 per cent. HCl solution, however, had no digestive effect on these parasites. It is suggested that the digestive effect *in vitro* is due to the *bromelin*, the proteolytic enzyme present in pineapple, which however is destroyed by the action of gastric juice.

Our observations, therefore, do not support the suggestion that fresh pineapple juice may be of value as an anthelmintic.

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SOCIETIES AND MEETINGS

THE AMERICAN ASSOCIATION OF SCIENTIFIC WORKERS AT COLUMBUS

A MEETING of the American Association of Scientific Workers was held at the Deshler-Wallick Hotel at Columbus, Ohio, at 4:00 P.M. on December 30, 1939, in connection with the meetings of the American Association for the Advancement of Science. Professor Kenneth V. Thimann occupied the chair. The general topic of the meeting was "Science and the Public." The first speaker was Mr. Watson Davis, editor of Science Service, who spoke briefly on the publicizing of science. The newspapers, he said, are the principal medium for the dissemination of science to the general public. In writing for the newspapers it is necessary to use an emotional approach tempered with intelligence. The science writers at this meeting of the American Association for the Advancement of Science wrote from 5,000 to 10,000 words each for the newspapers.

The next speaker was Dr. Julian Huxley, exchange lecturer from the British Association for the Advancement of Science. "Science and the Public" is a very broad subject, he said. After discussing the publicizing of science, he discoursed at some length on science and social relations. Man has mastered inanimate nature, but not human nature. We must get rid of the idea that the present state of society is a good one. At present we have no satisfactory machinery for coordination in society. Man must develop a social brain. Social science must be developed. Many scientists are opposed to social science, calling it pseudo-science. They have been impressed by the failure of the techniques of natural science when applied to social science. However, we should expect that in a totally different domain new techniques different from those used in the natural sciences will have to be developed. Totally new methods of measurement must be worked out. This is gradually being done in psychology, and it is to be expected that the same will be done in sociology. Already we have the measurement of public opinion by polls. All this takes time, but perhaps in a century politicians will be scientifically trained. Furthermore, an intellectual atmosphere suitable for the social sciences must be developed. This led him to a discussion of scientific humanism and fundamental human values.

The third speaker was Dr. Loring Andrews, of the Worldwide Broadcasting Foundation, who spoke on "Putting Science on the Air." Dr. Andrews has cooperated with the Boston-Cambridge Branch of the American Association of Scientific Workers in broadcasting science. Dr. Andrews discussed the interests and attitudes of the average radio listener and in particular the technique of putting science on the air. He emphasized the fact that a science broadcaster should be a master of the technique of radio broadcasting as well as have a thorough knowledge of science. The programs must be carefully prepared if they are to be successful. Many hours of work go into a fifteen-minute broadcast. He also discussed the various kinds of radio technique.

The last speaker was Professor Colston Warne, of Amherst College, who spoke on "The Relation of the Consumer Movement to Scientific Groups." Dr. Warne, who is president of Consumers Union, talked about the development of the consumer movement in the United States in the last decade, pointing out the difficulties the consumer had in making wise choices in purchasing because of the conflicting and frequently misleading claims made in advertising, etc. He also spoke of some of the present opposition to the consumer movement. He said that in the past the objectives of the consumer movement have been too narrowly conceived. He defined the objectives to be as follows:

(1) Dissemination of knowledge among consumers of the quality of goods, prices, etc.

(2) Securing of legislation in the interest of the consumer, such as food and drug laws.

(3) Securing a bounty of goods. Thus far the decision as to whether manufacturing plants shall operate or close has been solely in the hands of the management of corporations. Thus plants often close when consumers need the goods they could produce. Consumers should have a voice in deciding when plants shall operate or close, that is, a voice in management.

(4) Intelligent living in the twentieth century.

He said that scientific groups such as the American Association of Scientific Workers can aid in the movement.

ENOS E. WITMER

* Under grant from the Banting Research Foundation.

REPORTS

GRANTS FOR RESEARCH OF THE VIRGINIA ACADEMY OF SCIENCE

DURING the ten years from 1929 to 1938 the Research Committee of the Virginia Academy of Science has received 102 applications for aid, totaling $9,090.57, and has given out in the form of grants $4,028.17, or 44 per cent. of the amount requested. This $4,028.17 is made up of $400.00 received from the American Association for the Advancement of Science during 1935–1938, and $3,628.17 from the income account of the endowment fund of the academy. Of the 102 applications, 40 were granted in full, 22 in part, and 40 were granted nothing.

The 102 applications came from 19 different educational centers within the state. These applications represent practically every field of work in science in which people in Virginia are interested.

The purpose of the Research Committee is the encouragement of research in Virginia. How much has research been encouraged by the work of the committee? We have no definite data on this point, but there is rather general agreement that the interest in research is increasing and that more and more research work is being done.

Probably the best evidence we have concerning the effect of the grants on the amount of research work being done is to be found by studying the number of papers that have been read before the academy as a result of the grants and the number of papers that have been published.

Our analysis shows that, as a result of the 62 grants made (in full or in part), 48 papers have been "read" and 66 papers have been "published." Of course, we are unable to state how many of these would have been "read" and/or "published" without help from the Research Committee. However, we can contrast them with the similar output from the applications that were refused. From the 40 applications that were refused, only 12 papers have been "read" and 5 papers have been "published." Of course, here again the evidence is not conclusive, as one reason for refusing a grant to some of these was the fact that the project was not well chosen. However, on the whole, this evidence seems to indicate that the grants have encouraged research in Virginia.

The Research Committee was established for the encouragement of research in Virginia. Almost of necessity it has been obliged to abide by this purpose, as it has not had sufficient money to support research. It has accordingly tended to encourage the young man and the man in the smaller college rather than to support the seasoned worker.

Numerous letters indicate that the recipient of a grant is greatly encouraged and heartened that the Research Committee has thus approved and aided his work. For example: "The funds given me, while of intrinsic value, were prized by me mainly for the mental boost which they imparted. To feel that my fellow scientists thought well enough of me to give me a grant was like a tonic. To be active with some problem and to see that others wish to help in your search is one of the finest things that can come to one."

Apparently the college administration has reacted favorably to this recognition of the importance of scientific research in the work of the college. In three cases, 50 per cent. of a grant has been made on the condition that the administration would supply the other half. In each instance this has been done. One says, "It has helped make the administration realize the importance of research." Another says, "It brought me appointment as chairman of a committee on research in the college, and letters of approval from the administration."

"The Virginia Academy of Science in encouraging research through such grants will probably find the intangible results far more important than the tangible ones. Such things as enthusiasm, spirit of inquiry, a more intellectual life and increased research advantages . . . may be difficult to measure, but are highly important."

E. C. L. MILLER,
Secretary

GRANTS FOR RESEARCH OF THE AMERICAN GEOLOGICAL SOCIETY

THIRTEEN grants in support of special research projects were authorized by the council at the December, 1939, meeting, as follows:

Carl Tolman, Washington University, St. Louis, will investigate mineralization in the Lamotte-Frederickstown district of Missouri as one unit of a comprehensive study of the character, occurrence and genesis of the lead deposits of southeast Missouri. Although the deposits have been studied for years, many unsolved questions as to their origin still remain, and Professor Tolman hopes that in the Lamotte-Frederickstown district he may find some of the answers. $350.

R. Dana Russell, Louisiana State University, will continue his investigation of submarine deposits off the mouths of the Mississippi River. The work will be carried out during the year in cooperation with the United States Coast and Geodetic Survey. With a Piggot gun core samples will be taken from the sediments of the bottom for laboratory analysis and study. $700.

Amadeus W. Grabau, Peking, China, in searching the literature in connection with the preparation of Volume 5 of his series on *Paleozoic formations in the*

light of the pulsation theory. Professor Grabau went to China in 1920 as China Foundation research professor at the National University and chief paleontologist of the Chinese Geological Survey. In recent years opportunities and facilities for scientific research in China have been seriously impeded. The search of the literature is being made in American libraries by his assistant. $1,000.

B. L. Clark, University of California at Berkeley, will photograph and study Radiolaria from the Tertiary and Cretaceous formations of western North America to determine their value in stratigraphic correlation. Materials for study are being furnished through cooperation with oil companies of the west coast. $500.

A. Stoyanow, University of Arizona, will extend his studies of the Cretaceous of southeastern Arizona. Professor Stoyanow finds it necessary to compare fossils of his collection with those collected by others and will confer with paleontologists at Texas universities, at the National Museum in Washington, and at Philadelphia and Albany. $400.

T. S. Lovering, University of Michigan, will carry out mathematical experimental researches in thermal model theory in advancing his investigation of the flow of heat in the earth's crust during geologic time. The larger investigation has been under way for several years, and the grant will furnish research assistance, materials, and apparatus for establishing closer control of the thermal conductivity measurement. $900.

Leland Horberg, University of Illinois, will lead an expedition of three men into the eastern part of the Gros Ventre Range of northwestern Wyoming to complete a map, on which he has already spent considerable time, to study overthrust and high-angle faulting and the mechanics of the deformation, and to work out the diastrophic history. The area to be studied is claimed to be excellently located for structural studies, for within it are at least three types of structure related to both eastern and western Rocky Mountain trends. $430.

John Clark, Carnegie Museum, Pittsburgh, Pennsylvania, will spend four months with two assistants in Utah studying the Uinta formation with special reference to paleogeographic interpretations. He has already devoted two seasons to a study of the structural history of the Uinta Range, and the new work will contribute information on principles of fluviatile sedimentation and stream adjustment. $800.

F. G. Clapp, New York, N. Y., will prepare illustrations and complete a report on the geology of Afghanistan based on private field work during 1934–1938. $700.

Eugene N. Cameron, Columbia University, was granted assistance to complete the mapping of the Mount Prospect intrusive complex near Litchfield, Connecticut, and to provide chemical analyses of some of the rocks. The area includes about 12 square miles, and the complex series of rocks resembles the Cortlandt series of New York. The field work will require about 10 weeks. $475.

Robert T. Hill, Dallas, Texas, will continue his studies of the history of geology in the Southwest. Dr. Hill's popular articles on the Southwest are appearing currently in the *Dallas News,* and he is completing two volumes of more technical character. $1,800.

Bailey Willis, Stanford University, will undertake the revision of the geological map of North America, estimated to cost $7,500. The American Philosophical Society is cooperating with a grant of $1,000, and it is expected that other organizations will support the project. Mr. George W. Stose, of the United States Geological Survey, who collaborated with Professor Willis in preparing the existing map (1911 edition), will edit the revision and direct the drafting. Much new information has become available in the past 30 years in the United States, Canada, Mexico, the West Indies and adjacent parts of Central and South America. This will be classified and assembled in preparing an up-to-date map of the continent. $3,750.

Chester R. Longwell, Yale University, is directing the drafting of the tectonic map of the United States. A great many geologists have been cooperating with the Committee on Tectonics of the National Research Council, Division of Geology and Geography, in plotting the data available in different sections of the country. The American Association of Petroleum Geologists contributed a grant of $300 for drafting, and the Geological Society cooperates to make possible the final drafting of the first assembly of the sectional maps. $175.

SPECIAL ARTICLES

THE POSSIBLE IDENTITY OF VITAMIN H WITH BIOTIN AND COENZYME R

DURING work on the chemistry of vitamin H, the curative factor for egg-white injury, it became apparent that the properties of this vitamin were remarkably similar to those given in the literature for biotin, a yeast-growth factor, and for coenzyme R, a growth and respiration factor for many strains of the legume nodule organism Rhizobium.[1] The similarity in properties of biotin and coenzyme R has been pointed out during the past year by two independent

[1] F. E. Allison, S. R. Hoover and D. Burk, SCIENCE, 78: 217, 1933.

groups of workers. West and Wilson[2] concluded from a comparison of the growth effects of concentrates of biotin and coenzyme R on *Saccharomyces cerevisiae* and *Rhizobium trifolii* that biotin and coenzyme R are probably identical. A comparison of the effect of purified biotin and of concentrates of coenzyme R on Rhizobium also led Nilsson and coworkers[3] in Sweden to the same conclusion. Thus, any evidence which links vitamin H to one of these factors obviously tends to establish the identity of vitamin H with the other factor. The presumptive evidence derivable from the literature for the possible identity of these three factors rests on the general parallelism in their occurrence and distribution, in the similarity of their solubilities, in their behavior with precipitants and adsorbents and in their stability toward various reagents.

From the standpoint of the distribution there appear to be no data seriously conflicting with the possible identity of the three factors under discussion. It should be kept in mind, however, that the yeast- and Rhizobium-growth tests used to detect the presence of biotin and coenzyme R respectively are far more sensitive than the rat assay method used for vitamin H. The presence of traces of vitamin H activity might therefore remain undetected in the concentrations existing in various materials, as a result of which vitamin H might incorrectly appear to be less widely distributed. Liver and yeast are recognized as particularly rich sources of vitamin H, biotin, and coenzyme R. Interestingly enough, the reports indicate that both biotin and vitamin H are present in the liver bound to tissue proteins or other colloids in a water insoluble form and are liberated only after special treatment, as autolysis recorded for biotin[4] and vigorous autoclaving for vitamin H.[5] Other qualitative parallelisms of occurrence in natural materials exist but need not be detailed in this note. We would like to report, however, a recent observation we have made on the vitamin H activity of molasses. Since cane molasses has been reported as a particularly good source of both biotin[4] and coenzyme R,[6] it was very desirable to assay the material for vitamin H activity. Our assays indicate that cane molasses is likewise very potent in vitamin H activity.

From the standpoint of chemical and physical behavior the similarity in the nature of the materials responsible for the individual activities is marked.[5,7,8,9] All three substances are dialyzable, heat stable and resistant to treatment with acid or alkali. They are soluble in water and alcohol but insoluble in chloroform, ether and petroleum ether. All are adsorbed readily on charcoal. None is precipitated by lead acetate. Treatment of vitamin H or biotin with benzoyl chloride in pyridine results in an inactive product. Nitrous acid brings about inactivation of both substances. Acetylation of vitamin H with ketene, or acetylation of biotin with acetic anhydride in the presence of concentrated sulfuric acid causes inactivation. Reports on the electrophoretic behavior of coenzyme R coincide closely with that observed by ourselves with vitamin H.

With our growing realization of the similarity in properties between vitamin H and these two other factors we thought it would be of interest to test our purest vitamin H preparation for biotin and coenzyme R activity. We had succeeded mainly by means of electrodialysis in increasing the potency of vitamin H preparations from liver concentrates to 215 units per mg, a value greater than any reported hitherto. For comparison one of the less active fractions from the same electrodialysis experiment, assaying somewhat less than 8 units per mg, was selected. These two samples were sent for coenzyme R assay[10] to Dr. F. E. Allison and Francis W. Minor, of the Bureau of Agricultural Chemistry and Engineering of the U. S. Department of Agriculture, to whom we are greatly indebted and wish to express our appreciation. Confirmation and extension of these assays at Cornell was made possible by cultures generously furnished us by Dr. Allison. The biotin assays were carried out simultaneously, employing a modification of the method of Snell, Eakin and Williams.[4] The vitamin H assays were performed at Western Reserve University.[11]

It was found that our highest-purity vitamin H sample was extremely potent in coenzyme R activity. 0.01 gamma produced one billion cells in the assay procedure.[10] The most significant point, however, was the quantitative comparison between the two samples. Within experimental error (*ca.* $\pm$ 15%), the same ratio of coenzyme R potency was obtained as had been found for vitamin H activity. The more highly purified sample was on a basis of dry weight, some thirty times as potent in coenzyme R activity as the less pure sample of vitamin H. The biotin assays were likewise parallel. These results were confirmed and the comparisons extended to other electrodialysis samples, with results of the type obtained as indicated in Table 1. The preparation of the purified vitamin H and the

[2] P. M. West and P. W. Wilson, SCIENCE, 89: 607, 1939.
[3] R. Nilsson, G. Bjälfve and D. Burström, *Naturwissenschaften*, 27: 389, 1939.
[4] E. E. Snell, R. E. Eakin and R. J. Williams, *Jour. Am. Chem. Soc.*, 62: 175, 1940.
[5] P. György, *Jour. Biol. Chem.*, 131: 745, 1939.
[6] F. E. Allison and S. R. Hoover, *Jour. Bact.*, 27: 561, 1934.
[7] D. G. Clark, N. Y. (Cornell) Agr. Expt. Sta., *Memoir*, 196: 30 pp., 1936.
[8] S. R. Hoover and F. E. Allison, *Trans. 3rd Intern. Congr. Soil Sci.*, Oxford, 1: 158, 1935.
[9] F. Kögl and B. Tönnis, *Z. Physiol. Chem.*, 242: 43, 1936.
[10] F. E. Allison and F. W. Minor, *Soil Science*, 46: 473, 1938.
[11] Acknowledgment is made to Catharine S. Rose for valuable assistance in the vitamin H bio-assays.

detailed comparative assays will be presented elsewhere.

TABLE 1

CORRELATION OF VITAMIN H, BIOTIN, AND COENZYME R ASSAYS OF VARIOUS LIVER CONCENTRATE* ELECTRODIALYZATES

CELL	III	IV	V	VI
pH	4.7	3.4	3.1	3.0
SOLIDS mg/cc	4.6	2.7	1.9	1.2
VITAMIN H				
Units *a*/mg	6–8	52	215	160–200
Units/cc	30–40	140	400	200–250
BIOTIN cc β	0.00025	0.00005	0.00002	
COENZYME R cc γ	0.001	0.00025	0.0001	0.00014
RELATIVE CONC. PER MG				
Vitamin H	1	7.4	31	26
Biotin	1	8.5	30	
Coenzyme R	1	6.8	24	26

* A preparation assaying 20 units of vitamin H per mg was subjected to electrodialysis, in a series of 11 cells separated with Cellophane membranes. The vitamin H preparation was placed in cell III (cathode cell being No. I) and distilled water placed in the other cells. The electrodialysis was allowed to continue until the voltage (initial 4,500) remained constant (1,300) for 24 hours.

a Daily dose, applied for 30 days, required for complete protection against egg white injury.

β cc required to produce half maximum growth increase (*ca.* 500 per cent. increase over inoculum) of baker's yeast in 16 hours at 30° C. in 12 cc yeast growth medium deficient in biotin.

γ cc required to produce half maximum growth of *Rhizobium trifolii* strain 209 (*ca.* 800 million cells/cc) in 4 days at 28° C. in 25 cc synthetic sucrose-mineral-nitrate medium (inoculum negligible).

These experimental results add much strength to all the evidence that we have already collated indicating that these activities are various biological manifestations of the same substance. One must conclude from these data that they are either identical or indeed closely related compounds. We should like to emphasize that we do not regard the evidence adduced here as proving the identity of vitamin H with biotin and coenzyme R, but that it makes it indeed highly probable, and since it may be some time before final proof can be brought to bear on the question we feel that it is worth while to call attention to the probable identity involved. Obviously, final proof must await the testing of the crystalline compounds for these biological activities. We are attempting to obtain sufficient crystalline biotin for vitamin H assays. These assays of course require comparatively large amounts in terms of biotin activity.

It may be added that if the suggestion be substantiated that vitamin H is identical with biotin and coenzyme R, it will show that the two latter substances are significant in the vital economy of the mammal. Likewise, in view of the demonstrated role of coenzyme R in the respiration of Rhizobium, it is likely that vitamin H acts in ways other than simply to protect against egg white injury[12] and that it definitely functions in intermediate carbohydrate metabolism, as do various members of the so-called vitamin B complex, to which vitamin H, biotin and coenzyme R may well belong. The possible relationship or even identity of the latter to the gray-hair factor or other unisolated factors in the B complex remains to be determined.

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ISOLATION OF A CRYSTALLINE DERIVATIVE OF PANTOTHENIC ACID

IT has been shown[1,2] that the chick antidermatitis vitamin or pantothenic acid is composed of a hydroxy acid united in amide linkage with the amino group of β-alanine. While β-alanine has been isolated from concentrates of the vitamin,[1,2] neither the intact pantothenic acid nor the acid fragment has been obtained in pure crystalline condition. The discovery[3] of an organism which responds to the acid fragment alone has materially aided final solution of this substance.

Concentrates of the lactone of the hydroxy acid fragment were made essentially as previously described.[4,5] The sodium salt was then formed and acetylated, and the acetyl acid was converted to its acid chloride with $SOCl_2$, and this was poured into concentrated ammonia. The alcohol-soluble fraction of the reaction product was slowly crystallized from a small volume of acetone and alcohol as long needles.

These crystals were hydrolyzed with NaOH and tested by the use of hemolytic streptococcus, strain H69D.[3] Parenthetically it should be stated that the active substance of the liver fraction referred to previously[3] has been identified as nicotinic acid; it is thus possible to use a purely synthetic basal assay medium. Potency of added materials was judged both by quantitative estimation of turbidity,[6] as well as by titration of the acid produced during growth. The crystals were approximately half as active as 1.2 times an equal weight of alkali-treated "80 per cent. pantothenic acid" of Williams. This is not surprising when it is remem-

[12] The possibility that vitamin H might be identical with an anti-dermatitis factor for chick has been suggested by D. M. Hegsted, J. J. Oleson, C. A. Elvehjem and E. B. Hart in an abstract just come to hand (*Proc. Amer. Soc. Biol. Chem.*, New Orleans meeting, 1940).

[13] General Biochemicals Fellow.

[1] R. J. Williams, J. H. Truesdail, H. H. Weinstock, E. Rohrmann, C. M. Lyman and C. M. McBurney, *Jour. Am. Chem. Soc.*, 60: 2719, 1938.

[2] D. W. Woolley, H. A. Waisman, C. A. Elvehjem, *Jour. Am. Chem. Soc.*, 61: 977, 1939.

[3] D. W. Woolley, *Jour. Biol. Chem.*, 130: 417, 1939.

[4] D. W. Woolley, H. A. Waisman and C. A. Elvehjem, *Jour. Biol. Chem.*, 129: 673, 1939.

[5] J. J. Oleson, D. W. Woolley, C. A. Elvehjem, *Proc. Soc. Exp. Biol. and Med.*, 42: 151, 1939.

[6] D. W. Woolley, B. L. Hutchings, *Jour. Bact.*, 38: 285, 1939.

bered that a portion of the weight of the crystals is made up of the acetyl groups added. Maximum effect was obtained when 1 to 2 micrograms were added per cubic centimeter.

The mother liquor from the crystals (after hydrolysis) was approximately one fifth as active as the crystals. Recrystallization from alcohol-ether or from ethyl acetate-acetone or sublimation in high vacuum did not alter the activity detectably. A few milligrams of the crystals were hydrolyzed and the hydroxy acid was recombined with β-alanine, as previously described.[2] The product was highly active in promoting growth of *Lactobacillus casei*[7] (maximum effect wtih 0.1 micrograms per cc) as well as in causing growth response in rats fed a synthetic ration.[5,8]

While it is not impossible that the crystals are a mixture, the above facts make this possibility seem remote. It thus appears that both fragments of the pantothenic acid molecule have been obtained in a crystalline state.

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THE STRUCTURE OF PANTOTHENIC ACID

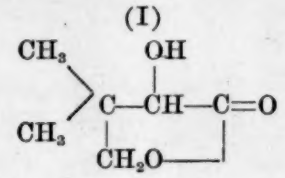
STUDIES on the structure of pantothenic acid were originated and carried forward in the laboratories of one of us[1,2,3,4,5] to the point where β-alanine[5] was recognized as one of its cleavage products and considerable information, in addition to that published, was obtained regarding the other portion of the molecule. A partial synthesis, using β-alanine ester, was also accomplished.[6]

Work on the chick anti-dermatitis factor was in progress in the Merck Research Laboratories when the announcement was made by Jukes[7] and Woolley, Waisman and Elvehjem[8] on the probable identity of the chick anti-dermatitis factor with pantothenic acid, and a cooperative arrangement was proposed to one of us (R.J.W.). By this arrangement all the techniques and experiences gained in the pantothenic acid studies were made available to the Merck Research Laboratories, where the crystalline lactone (cleavage product) was isolated and degraded, the exact structure of pantothenic acid determined, and its synthesis accomplished.

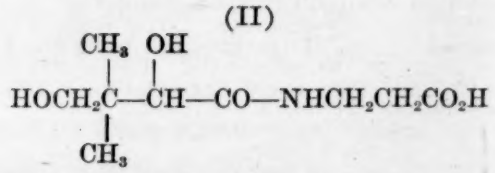
[7] Snell, E. E., F. M. Strong, W. H. Peterson, *Jour. Am. Chem. Soc.*, 60: 2825, 1938.
[8] G. H. Hitchings and Y. Subbarow, *Jour. Nutrition*, 18: 268, 1939.
[1] Williams, *et al.*, *Jour. Am. Chem. Soc.*, 55: 2912, 1933.
[2] R. J. Williams and Robin Moser, *Jour. Am. Chem. Soc.*, 56: 169, 1934.
[3] Williams, *et al.*, *Jour. Am. Chem. Soc.*, 60: 2719, 1938.
[4] *Ibid.*, 61: 454, 1939.
[5] Weinstock, *et al.*, *Jour. Am. Chem. Soc.*, 61: 1421, 1939.
[6] R. J. Williams, SCIENCE, 89: 486, 1939.
[7] T. Jukes, *Jour. Am. Chem. Soc.*, 61: 975, 1939.
[8] Woolley, Waisman and Elvehjem, *Jour. Am. Chem. Soc.*, 61: 977, 1939.

The study was pursued in the Merck Research Laboratories with large amounts of liver concentrate. Purification methods were devised which gave concentrates containing 3 to 40 per cent. of barium pantothenate, from which the pure crystalline lactone (m.p. 91–92°) was obtained readily. Its composition corresponded to $C_6H_{10}O_3$, and its structure was shown by degradation to be that of α-hydroxy-β,β-dimethyl-γ-butyrolactone (I) which has been synthesized and condensed with β-alanine to produce physiologically active pantothenic acid (II).

(I)



(II)



This work in the Merck Research Laboratories was done by Drs. E. T. Stiller, J. C. Keresztesy and J. Finkelstein, and the results in detail will be published elsewhere under their authorship. An accompanying paper will present the unpublished data up to the point where the cooperation began.

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PRELIMINARY STUDIES ON MATING REACTIONS OF ENUCLEATE FRAGMENTS OF PARAMECIUM BURSARIA

RECENT studies by several investigators[1] have shown that there are distinct mating types in various species of Paramecium. Under appropriate conditions, individuals belonging to different mating types will agglutinate when they are mixed and later form pairs. Such agglutination has been called the "mating reaction." The purpose of the present investigation was to answer the question: Do enucleate fragments of Paramecium exhibit the mating reaction?

Paramecium bursaria—the green Paramecium—is especially favorable for the present study because of (1) the viability of fragments, (2) large size of the micronucleus, (3) permanence of mating type and (4) ease of cutting. Enucleate fragments of this species may remain alive for as long as four days. These fragments show a surprisingly normal behavior. In

[1] T. M. Sonneborn, *Proc. Nat. Acad. Sci.*, 23: 378–385, 1937; R. F. Kimball, *Proc. Nat. Acad. Sci.*, 23: 469–474, 1937; H. S. Jennings, *Proc. Nat. Acad. Sci.*, 24: 112–120, 1938; T. M. Sonneborn, *Proc. Amer. Phil. Soc.*, 79: 411–434, 1938; H. S. Jennings, *Genetics*, 24: 202–233, 1939.

the present study fragments were used for testing immediately after cutting. After staining, the micronucleus or part of the macronucleus could easily be detected if present in the fragment used, since the micronucleus in this species (especially in the two races used in the present investigation) is large and conspicuous. Apparently each clone of *P. bursaria* retains permanently its characteristic mating type.[2] This permanence of mating type affords uniform and constant material for study. In this species the animals show a tendency to creep slowly over the bottom of the container, a behavior which facilitates cutting with a glass needle to such an extent that large numbers of fragments may be obtained.

Two races of *P. bursaria* (*Gr14* and McD_3) belonging to two different mating types were used in the present investigation. Each of the two races has a single, large, deeply staining micronucleus. After a definite mating reaction had been observed, the fragments were fixed and stained to determine whether the micronucleus or part of the macronucleus was present.

Enucleate fragments of either mating type were found to give the normal mating reaction with whole animals of the other mating type. Mating reaction between enucleate fragments and whole animals seems to be identical with that between whole animals. Control experiments showed that fragments never agglutinate with whole animals of the same mating type.

The mating reaction also occurs between two enucleate fragments belonging to two different mating types. Control experiments showed that the mating reaction never occurs between enucleate fragments of the same mating type. Thus the cytoplasm alone (in the absence of the nuclei) exhibits the reactivity and diversity of mating type. Of course this reactivity may be due to the retention of influence of the nuclei which have just been removed.

Further investigations are projected, and the findings here noted will be presented in detail later.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A METHOD OF SUBSTITUTING PINE SAPWOOD FOR MALT AGAR IN CULTURING TEST FUNGI

THE method described in this article is the result of experiments made in an effort to substitute pine sapwood for malt agar medium in testing the toxicity of preservatives in wood. The results obtained by the use of Ponderosa pine sapwood as a medium for growing the wood-rotting and sap-staining fungi used in the method were so consistently favorable and the reduction in time as well as the low-cost of materials proved so encouraging that it was believed of interest to present the method to other workers for trial and comment.

The containers used are half-gallon, square, wide-mouth Kerr jars, fitted with metal, self-sealing screw caps. Two pieces of Ponderosa pine sapwood, $\frac{1}{4}$ inch thick, $2\frac{3}{4}$ inches wide and $6\frac{7}{8}$ inches long, are placed on a grooved piece of pine sapwood in such a manner as to form a V-shaped trough when the jar is placed on its side. The grooved piece is $\frac{5}{8}$ inch thick, $1\frac{3}{8}$ inches wide and $6\frac{7}{8}$ inches long, with the groove about $\frac{7}{8}$ inch wide and $\frac{1}{4}$ inch deep (see Fig. 1). At the bottom of the V is placed a length of glass tubing $6\frac{3}{4}$ inches long and about $\frac{3}{8}$ inch in outside diameter. The pine test pieces, $\frac{1}{4} \times 1\frac{1}{2} \times 2$ inches in size, rest with the $\frac{1}{4} \times 1\frac{1}{2}$ inch edge on the glass tubing, to prevent contact between the two rows of test pieces.

The wood pieces and the glass tube are placed in position in the jar and sufficient water added (about 100 cc) to equal the weight of the three wood pieces. A pad of cotton is placed in the metal cap, which is loosely screwed to the jar. The jar and contents can then be sterilized. After sterilizing and cooling the jars and contents, the test fungus inoculum can be placed at various points over the surfaces of the two

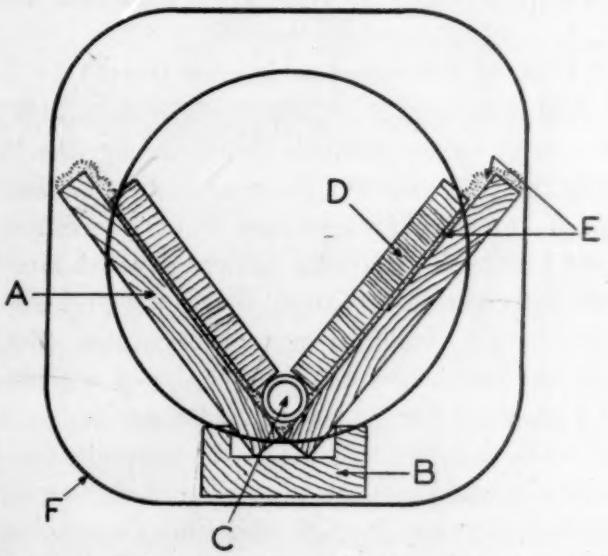

FIG. 1. A, V board. B, Grooved base block. C, Glass tubing. D, Test block. E, Fungus mat. F, Square half-gallon fruit jar.

V boards. Three to six individual inocula to each board serve to cover it with a vigorous growth in from 10 to 15 days. The decay-producing fungus *Lenzites trabea* and the various stain fungi isolated from window sash thrive on this medium. When thicker V boards are used, care must be taken to prevent too high a moisture content in the wood.

[2] See H. S. Jennings, *Genetics*, 24: 202–233, 1939.

After the required growth has been reached, the test pieces are moistened by adding a known amount of sterile water to each one by means of a sterilized pipette. The pieces are then placed in position over the glass tube with one of the $1\frac{1}{2} \times 2$ inch faces in contact with the fungus mat. From 8 to 10 test pieces can be placed in a jar at one time. With care in preventing contamination of the cultures, they can be used over again as soon as the vigor of the fungus is renewed on the V boards.

The method provides a much greater capacity for test pieces than does the Kolle flask and the jars are easily prepared and cleaned. The preparation and sterilization of agar media is eliminated with considerable saving in cost. By growing on their natural substrate, wood, the test fungi maintain their vigor and can be used over again in the cultural jars so long as they remain contamination free and show vigorous growth. The moisture requirements are easily met, as the cultures grow older, by adding sterilized water to the wood medium or to the bottom of the jar.

For preliminary tests of new toxicants in wood, for testing sections cut from treated millwork or other wood products to determine the effectiveness of the preservative treatment, and for testing the relative resistance of various species of wood to decay, this method has proved of real value.

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FILING PHOTOGRAPHIC COPIES OF ARTICLES

IN view of the recent article by Harold P. Brown and James A. Austin in SCIENCE, December 15, 1939, a few notes on the methods developed by this library during the past year for filing photographic copies of original literature articles may be of interest.

Our library is the main library devoted largely to industrial chemical research for a medium size corporation. In building up photographic files, our policy has been to get photostat copies of articles under five pages and film copies of the longer ones. In the files, we have found that it is more convenient to interfile the films and photostats as a skeleton journal file—alphabetically by journal and then chronologically. This is expansible to almost any degree and eliminates extensive cataloguing, since *Chemical Abstracts* serves as a useful index. In the future, the abstract in *Chemical Abstracts* will be stamped "Filed" in the margin to show that a copy of the article is available in our library.

We have found, as did Brown and Austin, that the majority of technical articles are comparatively short, and the following scheme was devised for film strips: Correspondence size manila folders were lined with lengthwise stitched (and backstitched one half inch to eliminate ripping) pockets of good quality rag paper, 5 pockets to each side of the folder, or 10 pockets in all—giving an average storage capacity for each folder of the equivalent of 110 pages of magazine or book material when 35 mm film is used. Since the use of paper for the pockets eliminates the necessity of separate labels; identification may be made directly on each pocket. If articles need to be cut to fit the folder length, identification (if not already on each strip of film as order blank duplication) is marked with India ink on the leader strip, as well as on the pocket.

An illuminated hand viewer is almost a necessity in identifying film strips which are ready for filing or for rapid location of data in tables, when only one or two figures are wanted. Also we have found that a small movable table for the reading machine simplifies the problem of use. It is ordinarily kept near the desk of the bibliographer where it can be used for reading or placed directly behind the typewriter to copy data.

ELMA T. EVANS
R. MAX GOEPP, JR.

ATLAS POWDER COMPANY

BOOKS RECEIVED

ARRAUD, C.-A. *Diathermie Chirurgicale.* Pp. 216. 52 figures. Gauthier-Villars, Paris. 50 fr.

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